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```
%%%% AN 88 LINE TOPOLOGY OPTIMIZATION CODE Nov, 2010 %%%%
%%%Aren Almeida 1225408288%%%%
%function top88(nelx,nely,volfrac,penal,rmin,ft)
nelx=360;
nely=128;
volfrac=0.8;
penal=3;
rmin=3;
ft=1;
```

MATERIAL PROPERTIES

```
E0 = 1;
Emin = 1e-9;
nu = 0.3;
```

PREPARE FINITE ELEMENT ANALYSIS

```
A11 = [12 3 -6 -3; 3 12 3 0; -6 3 12 -3; -3 0 -3 12];
A12 = [-6 -3 0 3; -3 -6 -3 -6; 0 -3 -6 3; 3 -6 3 -6];
B11 = [-4 3 -2 9; 3 -4 -9 4; -2 -9 -4 -3; 9 4 -3 -4];
B12 = [ 2 -3 4 -9; -3 2 9 -2; 4 9 2 3; -9 -2 3 2];
KE = 1/(1-nu^2)/24*([A11 A12;A12' A11])+nu*[B11 B12;B12' B11]);
nodenrs = reshape(1:(1+nelx)*(1+nely),1+nely,1+nelx);
edofVec = reshape(2*nodenrs(1:end-1,1:end-1)+1,nelx*nely,1);
edofMat = repmat(edofVec,1,8)+repmat([0 1 2*nely+[2 3 0 1] -2 -1],nelx*nely,1);
iK = reshape(kron(edofMat,ones(8,1))',64*nelx*nely,1);
jK = reshape(kron(edofMat,ones(1,8))',64*nelx*nely,1);
% DEFINE LOADS AND SUPPORTS (HALF MBB-BEAM)
F = sparse(2,1,1,2*(nely+1)*(nelx+1),1);
U = zeros(2*(nely+1)*(nelx+1),1);
fixeddofs = union([1:2:2*(nely+1)],[2*(nelx+1)*(nely+1)]);
alldofs = [1:2*(nely+1)*(nelx+1)];
freedofs = setdiff(alldofs,fixeddofs);
```

PREPARE FILTER

```

iH = ones(nelx*nely*(2*(ceil(rmin)-1)+1)^2,1);
jH = ones(size(iH));
sH = zeros(size(iH));
k = 0;
for i1 = 1:nelx
    for j1 = 1:nely
        e1 = (i1-1)*nely+j1;
        for i2 = max(i1-(ceil(rmin)-1),1):min(i1+(ceil(rmin)-1),nelx)
            for j2 = max(j1-(ceil(rmin)-1),1):min(j1+(ceil(rmin)-1),nely)
                e2 = (i2-1)*nely+j2;
                k = k+1;
                iH(k) = e1;
                jH(k) = e2;
                sH(k) = max(0,rmin-sqrt((i1-i2)^2+(j1-j2)^2));
            end
        end
    end
end
H = sparse(iH,jH,sH);
Hs = sum(H,2);

```

INITIALIZE ITERATION

```

x = repmat(volfrac,nely,nelx);
xPhys = x;
loop = 0;
change = 1;

```

START ITERATION

```

while change > 0.01

```

```

loop = loop + 1;

```

FE-ANALYSIS

```

sK = reshape(KE(:)*(Emin+xPhys(:)').^penal*(E0-Emin)),64*nelx*nely,1);
K = sparse(iK,jK,sK);
K = (K+K')/2;
U(freedofs, :) = K(freedofs,freedofs)\F(freedofs, :);

```

OBJECTIVE FUNCTION AND SENSITIVITY ANALYSIS

```

c=0;
dc=0;
for i = 1:size(F,2)
    Ui = U(:,i);
    ce = reshape(sum((Ui(edofMat)*KE).*Ui(edofMat),2), nely,nelx);
    c = c + sum(sum((Emin+xPhys.^penal*(E0-Emin)).*ce));
    dc = dc - penal*(E0-Emin)*xPhys.^((penal-1).*ce);
end
dv = ones(nely,nelx);

```

FILTERING/MODIFICATION OF SENSITIVITIES

```
if ft == 1
    dc(:) = H*(x(:).*dc(:)./Hs./max(1e-3,x(:)));
elseif ft == 2
    dc(:) = H*(dc(:)./Hs);
    dv(:) = H*(dv(:)./Hs);
end
```

OPTIMALITY CRITERIA UPDATE OF DESIGN VARIABLES AND PHYSICAL DENSITIES

```
l1 = 0; l2 = 1e9; move = 0.2;
while (l2-l1)/(l1+l2) > 1e-3
    lmid = 0.5*(l2+l1);
    xnew = max(0,max(x-move,min(1,min(x+move,x.*sqrt(-dc./dv/lmid)))));
    xPhys = xnew;
    if sum(xPhys(:)) > volfrac*nelx*nely
        l1 = lmid;
    else
        l2 = lmid;
    end
end
change = max(abs(xnew(:)-x(:)));
x = xnew;
```

PRINT RESULTS

```
fprintf(' It.:%5i Obj.:%11.4f Vol.:%7.3f ch.:%7.3f\n',loop,c, mean(xPhys(:)),change);
```

It.: 1 Obj.: 220.5076 Vol.: 0.800 ch.: 0.200

It.: 2 Obj.: 140.5816 Vol.: 0.800 ch.: 0.200

It.: 3 Obj.: 135.9342 Vol.: 0.800 ch.: 0.200

It.: 4 Obj.: 133.1070 Vol.: 0.800 ch.: 0.200

It.: 5 Obj.: 130.6904 Vol.: 0.800 ch.: 0.200

It.: 6 Obj.: 129.0650 Vol.: 0.800 ch.: 0.200

It.: 7 Obj.: 128.0867 Vol.: 0.800 ch.: 0.200

It.: 8 Obj.: 127.2975 Vol.: 0.800 ch.: 0.192

It.: 9 Obj.: 126.7653 Vol.: 0.800 ch.: 0.187

It.: 10 Obj.: 126.3262 Vol.: 0.800 ch.: 0.200

It.: 11 Obj.: 125.9512 Vol.: 0.800 ch.: 0.200

It.: 12 Obj.: 125.5400 Vol.: 0.800 ch.: 0.200

It.: 13 Obj.: 125.1994 Vol.: 0.800 ch.: 0.200

It.: 14 Obj.: 124.9561 Vol.: 0.800 ch.: 0.200

It.: 15 Obj.: 124.7824 Vol.: 0.800 ch.: 0.200

It.: 16 Obj.: 124.5964 Vol.: 0.800 ch.: 0.200

It.: 17 Obj.: 124.3591 Vol.: 0.800 ch.: 0.200

It.: 18 Obj.: 124.1661 Vol.: 0.800 ch.: 0.200

It.: 19 Obj.: 123.9272 Vol.: 0.800 ch.: 0.200

It.: 20 Obj.: 123.7424 Vol.: 0.800 ch.: 0.200

It.: 21 Obj.: 123.5384 Vol.: 0.800 ch.: 0.200

It.: 22 Obj.: 123.3479 Vol.: 0.800 ch.: 0.200

It.: 23 Obj.: 123.1424 Vol.: 0.800 ch.: 0.200

It.: 24 Obj.: 122.9561 Vol.: 0.800 ch.: 0.197

It.: 25 Obj.: 122.7888 Vol.: 0.800 ch.: 0.164

It.: 26 Obj.: 122.6466 Vol.: 0.800 ch.: 0.141

It.: 27 Obj.: 122.5197 Vol.: 0.800 ch.: 0.128

It.: 28 Obj.: 122.4214 Vol.: 0.800 ch.: 0.153

It.: 29 Obj.: 122.3133 Vol.: 0.800 ch.: 0.150

It.: 30 Obj.: 122.2445 Vol.: 0.800 ch.: 0.142

It.: 31 Obj.: 122.1876 Vol.: 0.800 ch.: 0.125

It.: 32 Obj.: 122.1640 Vol.: 0.800 ch.: 0.114

It.: 33 Obj.: 122.1284 Vol.: 0.800 ch.: 0.104

It.: 34 Obj.: 122.0975 Vol.: 0.800 ch.: 0.099

It.: 35 Obj.: 122.0612 Vol.: 0.800 ch.: 0.100

It.: 36 Obj.: 122.0253 Vol.: 0.800 ch.: 0.107

It.: 37 Obj.: 121.9803 Vol.: 0.800 ch.: 0.106

It.: 38 Obj.: 121.9511 Vol.: 0.800 ch.: 0.101

It.: 39 Obj.: 121.9141 Vol.: 0.800 ch.: 0.093

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It.: 42 Obj.: 121.8896 Vol.: 0.800 ch.: 0.110

It.: 43 Obj.: 121.8779 Vol.: 0.800 ch.: 0.109

It.: 44 Obj.: 121.8547 Vol.: 0.800 ch.: 0.136

It.: 45 Obj.: 121.8415 Vol.: 0.800 ch.: 0.129

It.: 46 Obj.: 121.8277 Vol.: 0.800 ch.: 0.142

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It.: 48 Obj.: 121.8244 Vol.: 0.800 ch.: 0.147

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It.: 51 Obj.: 121.8305 Vol.: 0.800 ch.: 0.171

It.: 52 Obj.: 121.8210 Vol.: 0.800 ch.: 0.160

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It.: 68 Obj.: 121.7066 Vol.: 0.800 ch.: 0.184

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It.: 74 Obj.: 121.6780 Vol.: 0.800 ch.: 0.168

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It.: 76 Obj.: 121.6520 Vol.: 0.800 ch.: 0.134

It.: 77 Obj.: 121.6423 Vol.: 0.800 ch.: 0.200

It.: 78 Obj.: 121.6450 Vol.: 0.800 ch.: 0.195

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It.: 80 Obj.: 121.6392 Vol.: 0.800 ch.: 0.136

It.: 81 Obj.: 121.6364 Vol.: 0.800 ch.: 0.120

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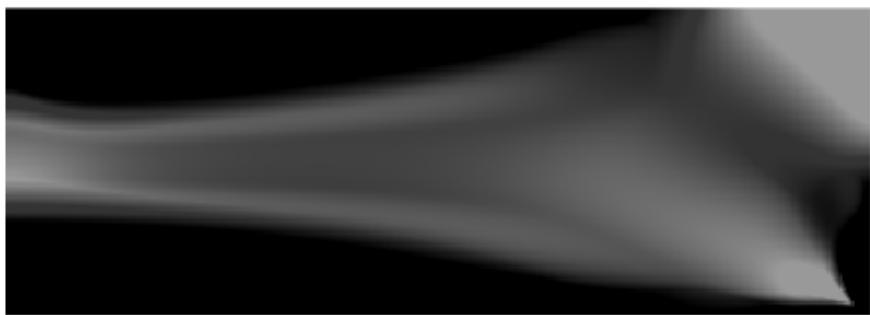
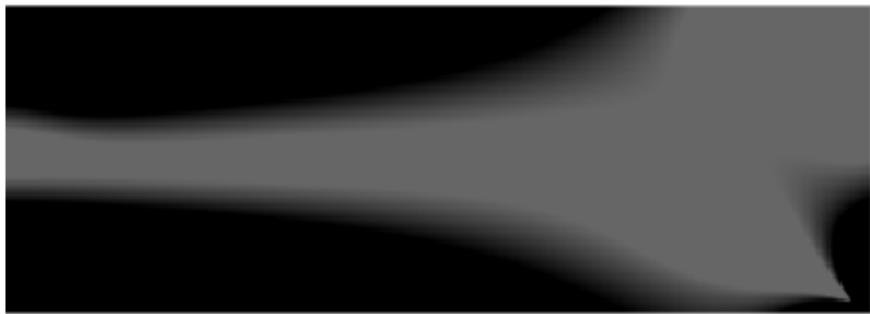
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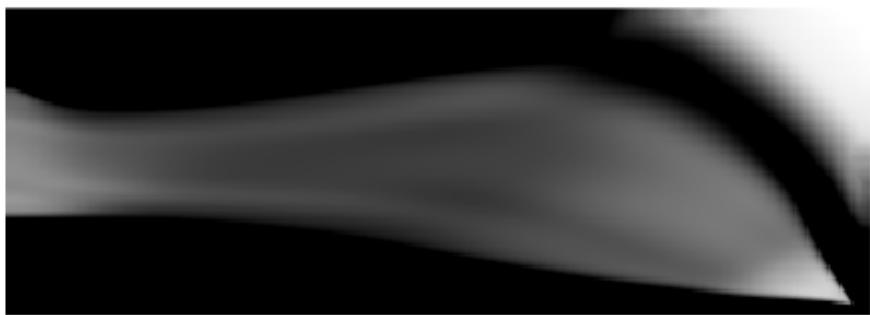
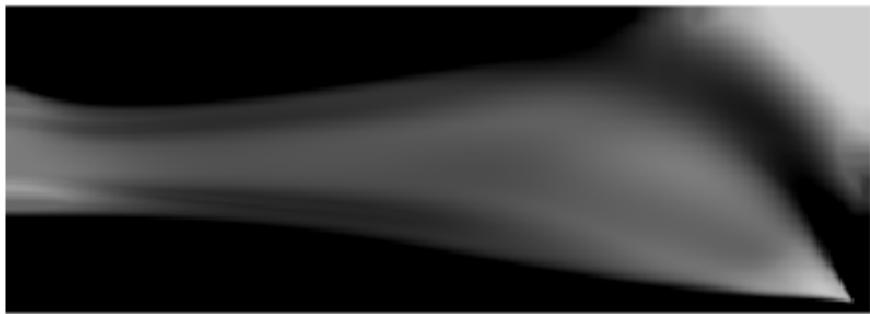
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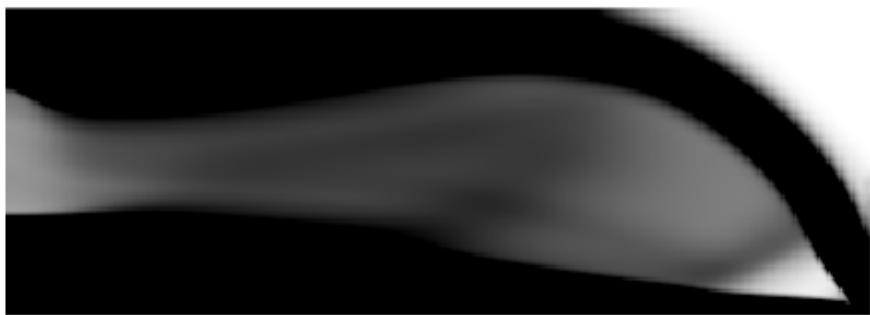
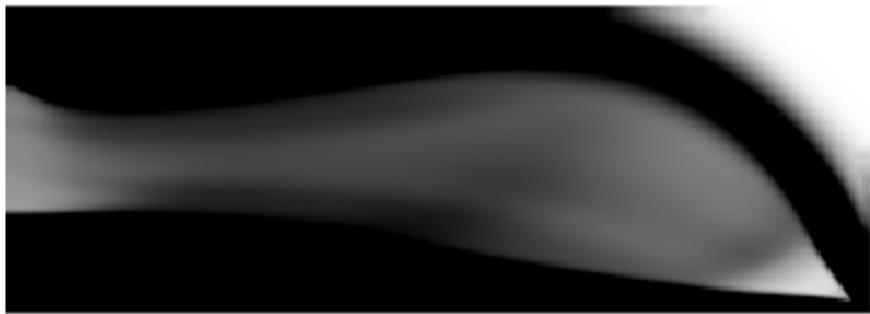
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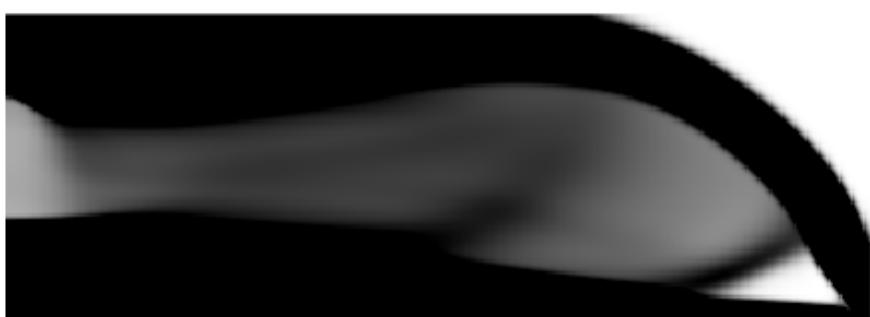
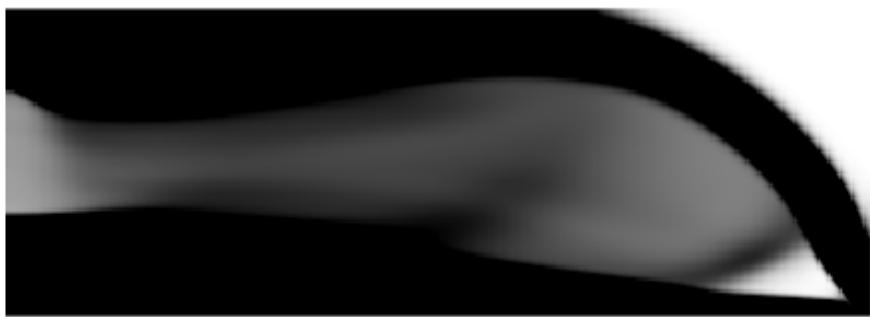
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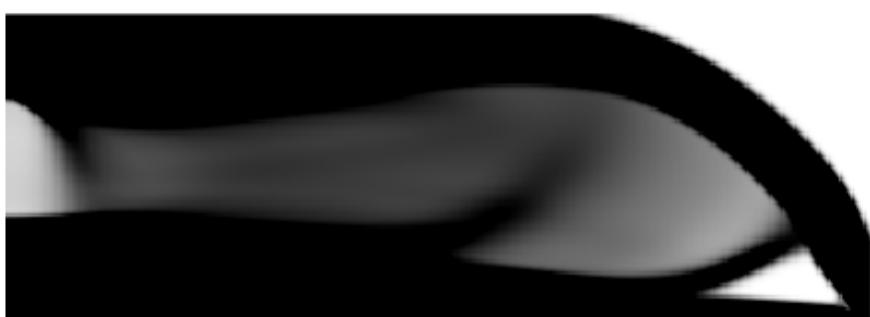
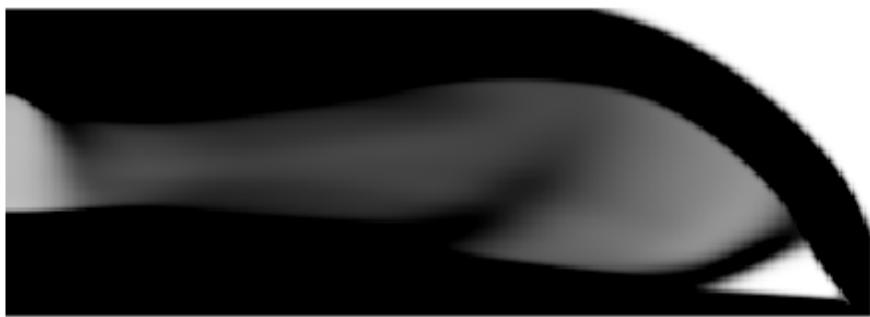
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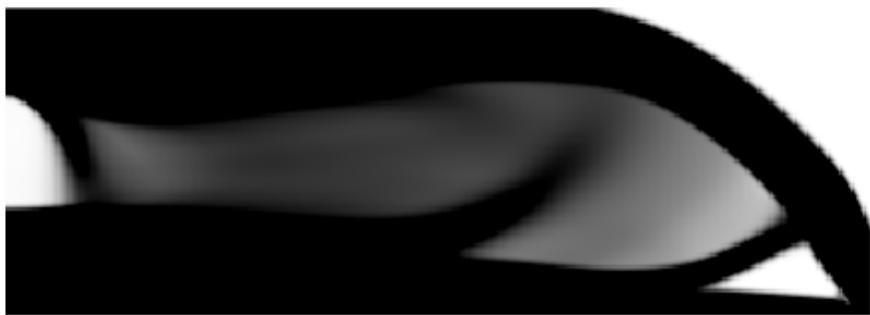
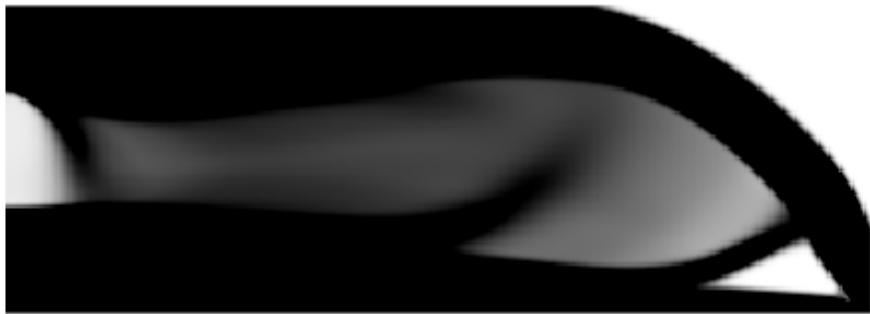


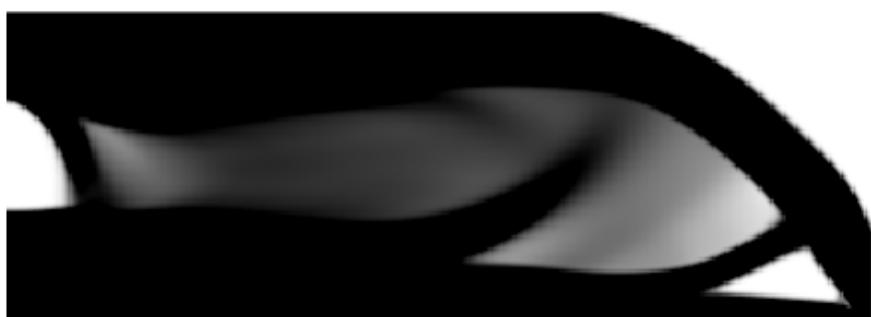
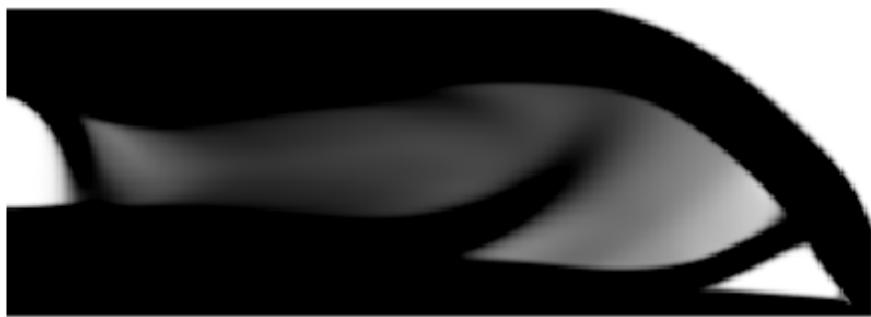


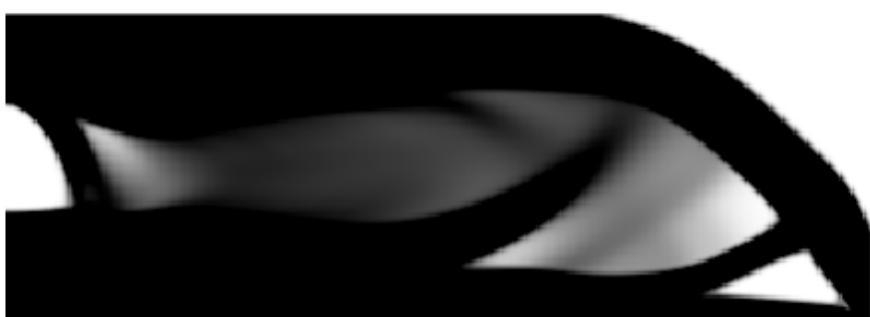
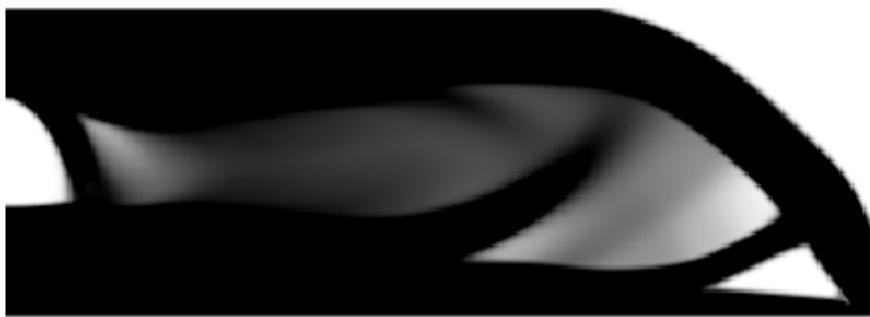


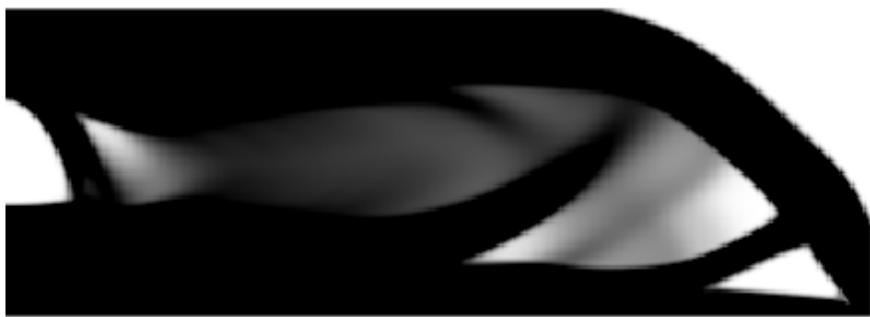


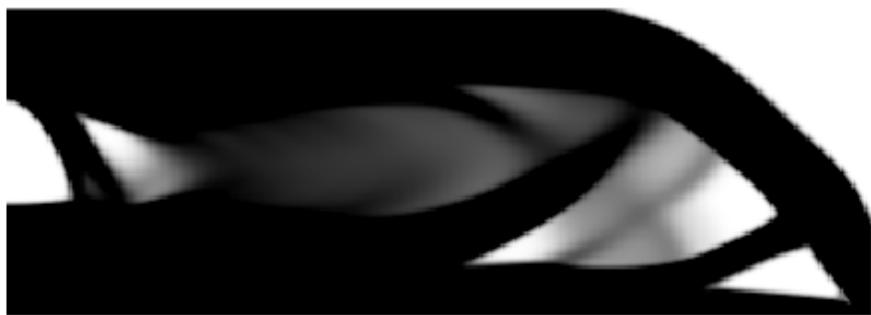




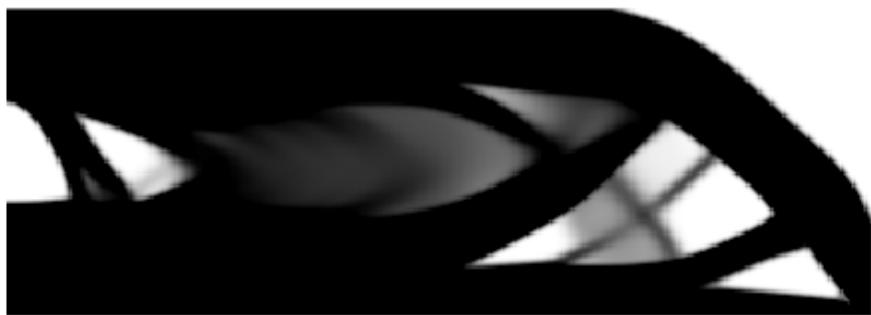


















































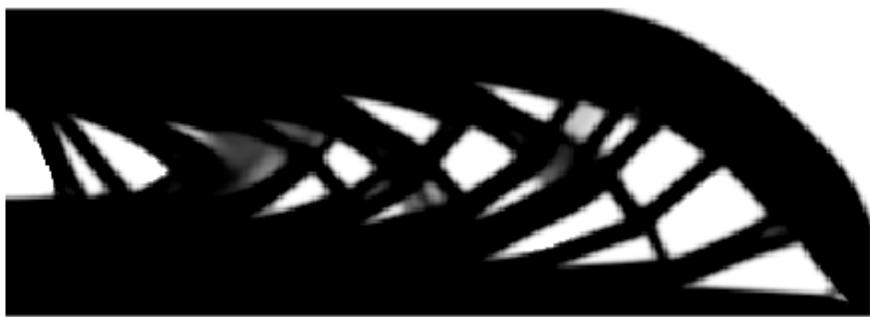




















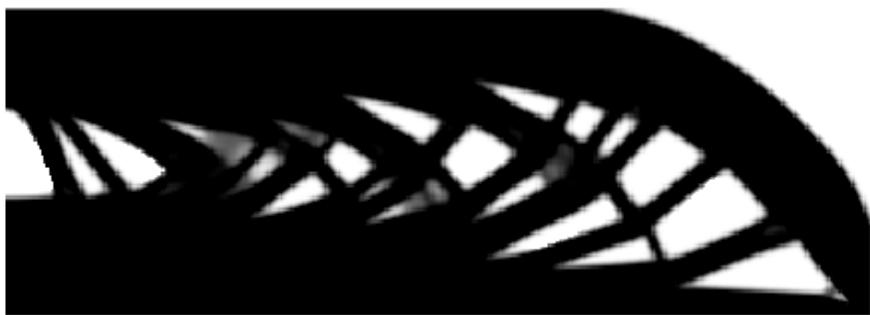


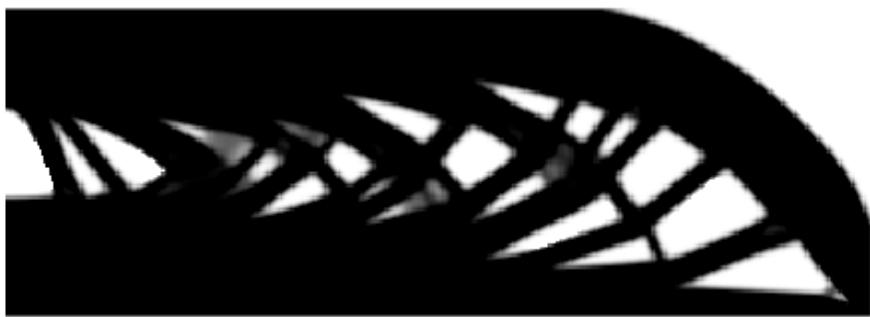


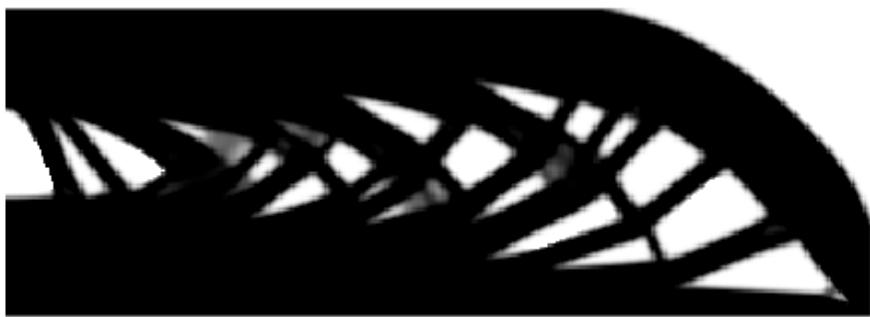


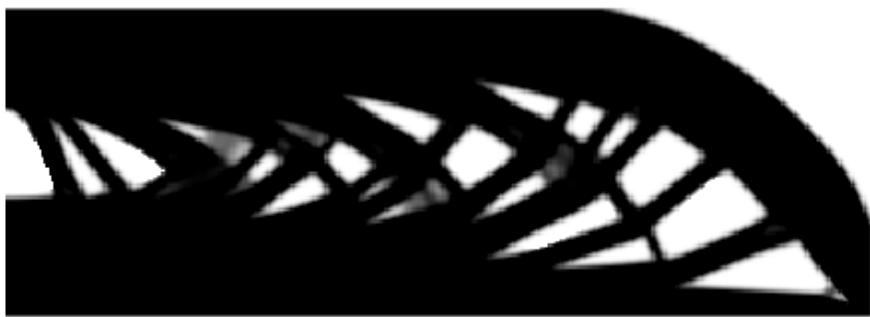


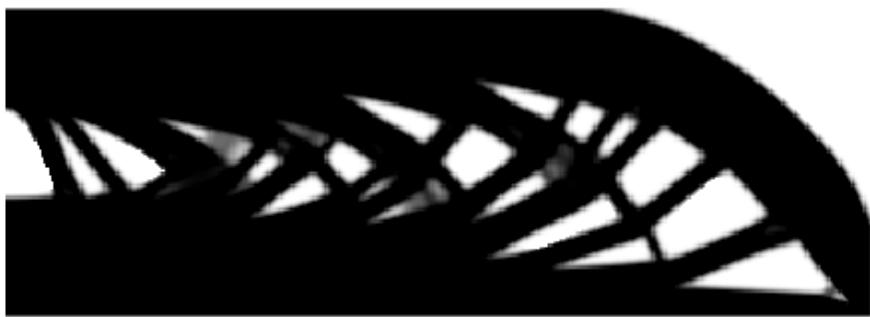


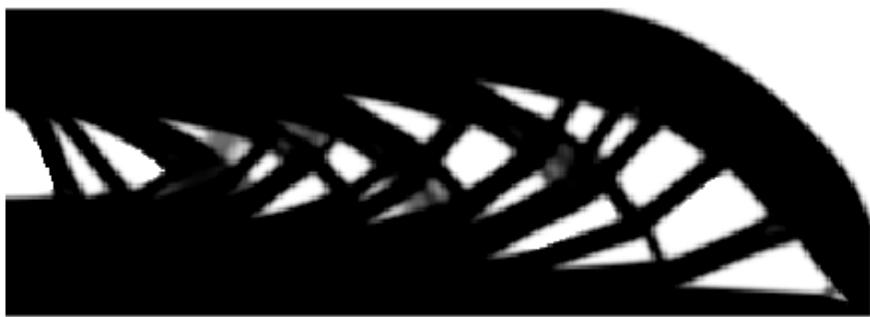


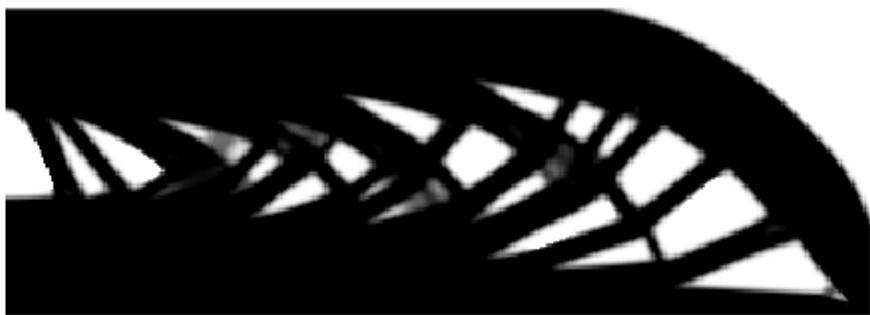


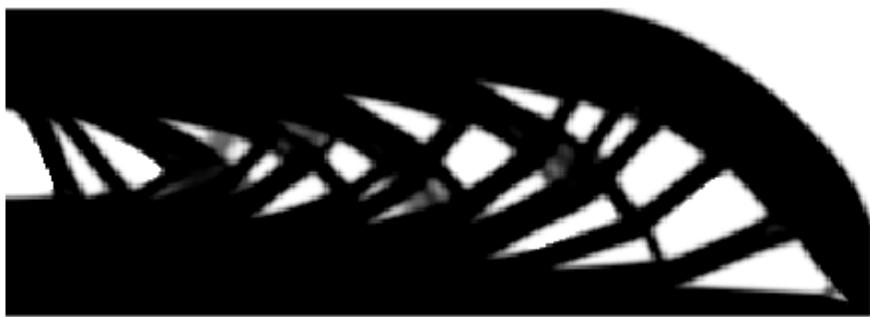


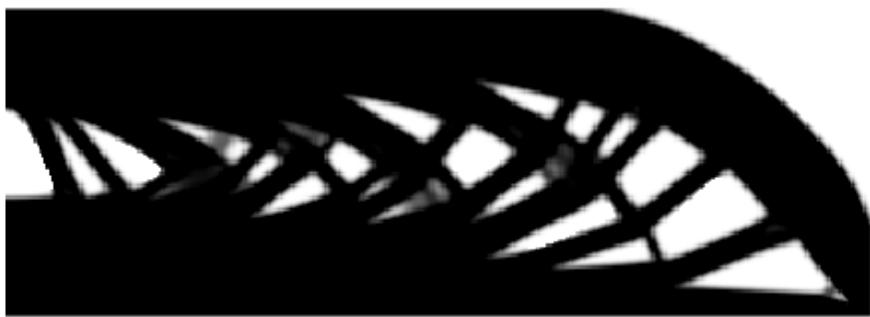


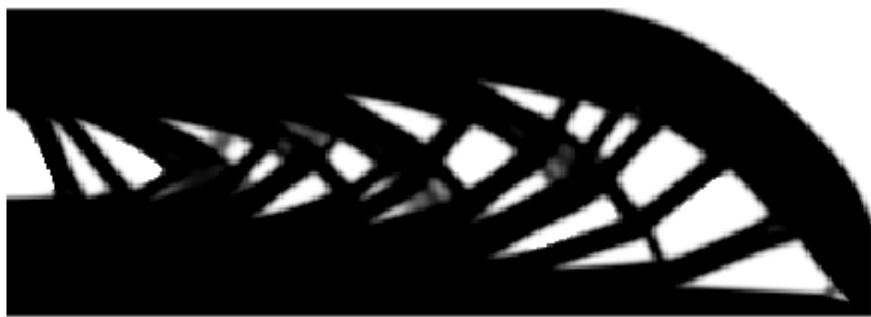


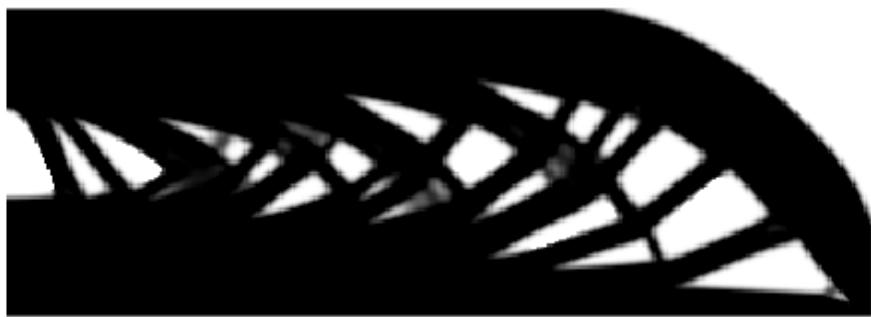


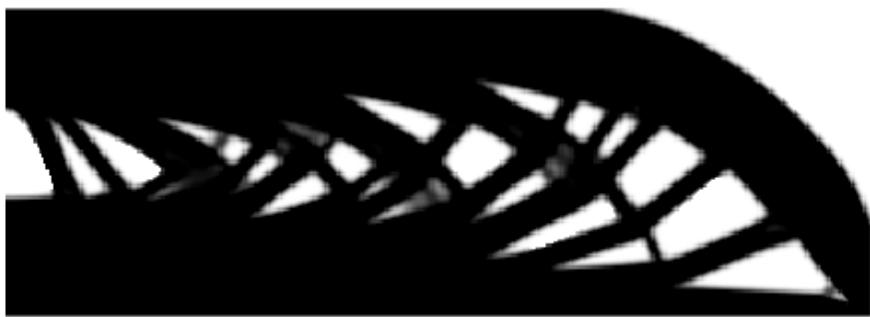




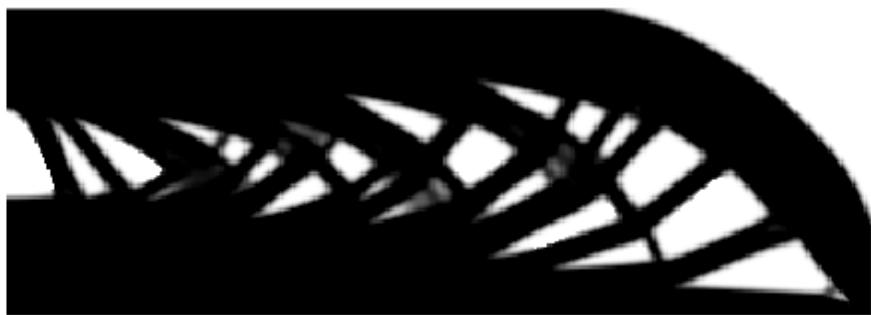


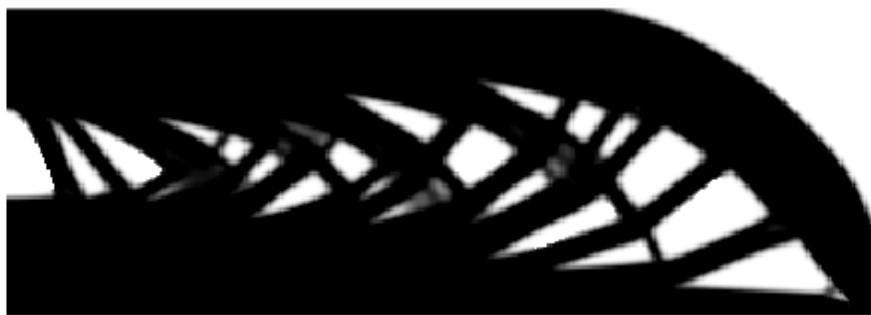


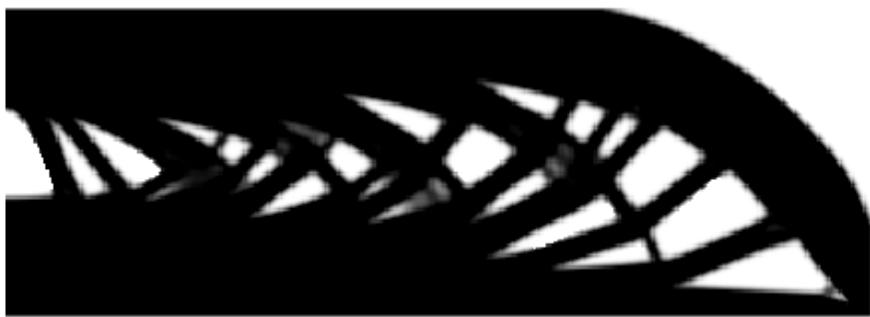


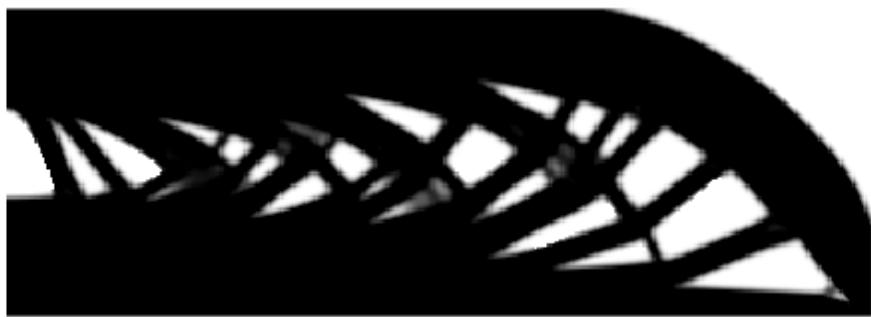


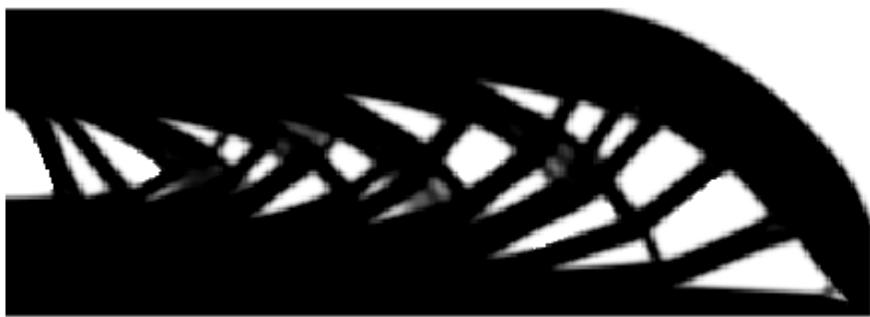


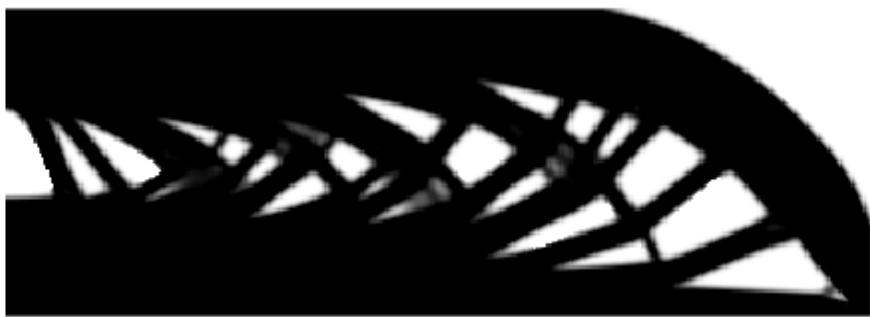


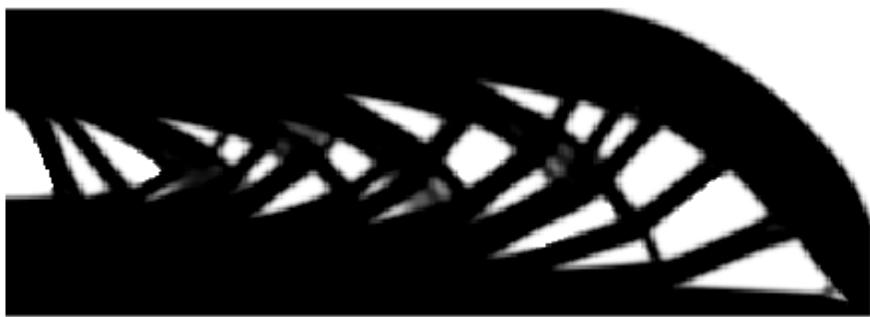


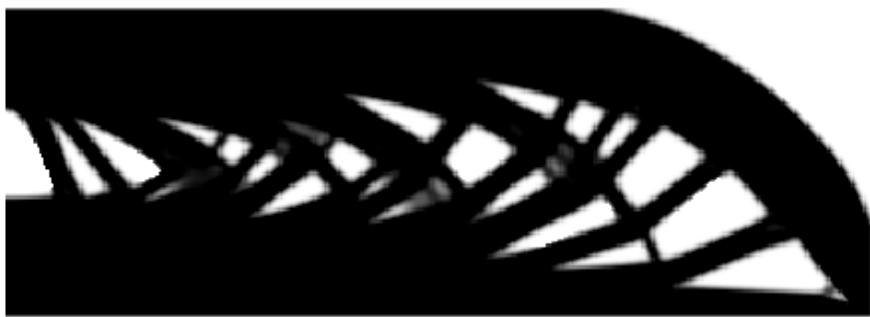


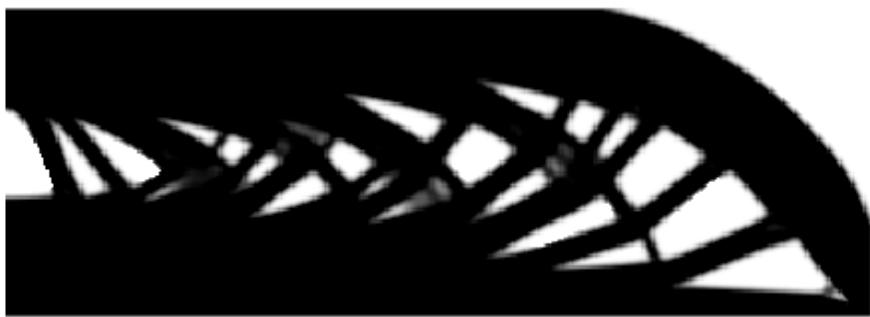


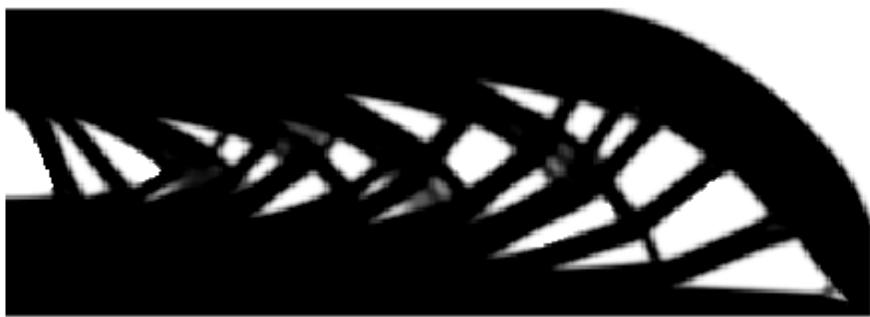


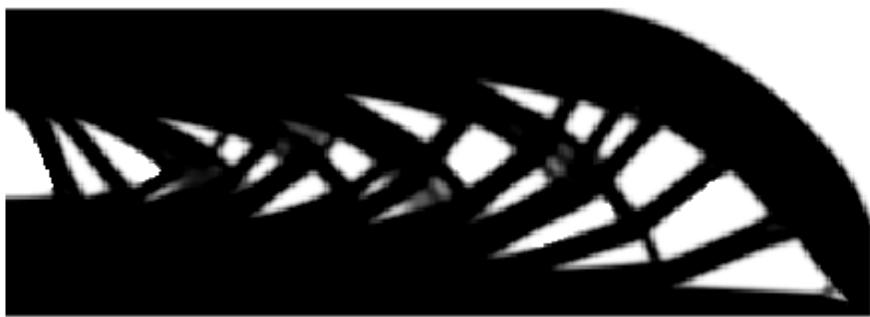


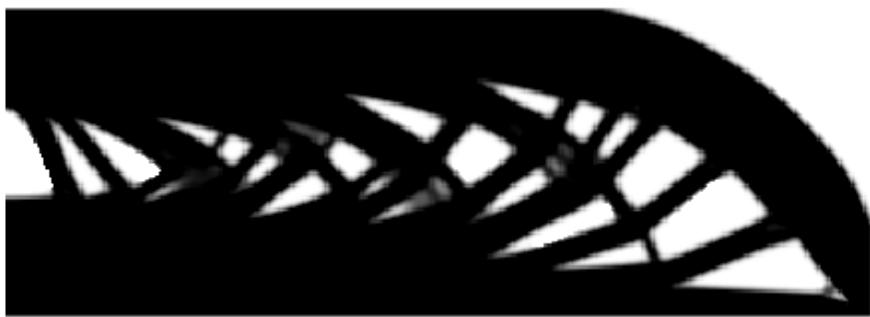


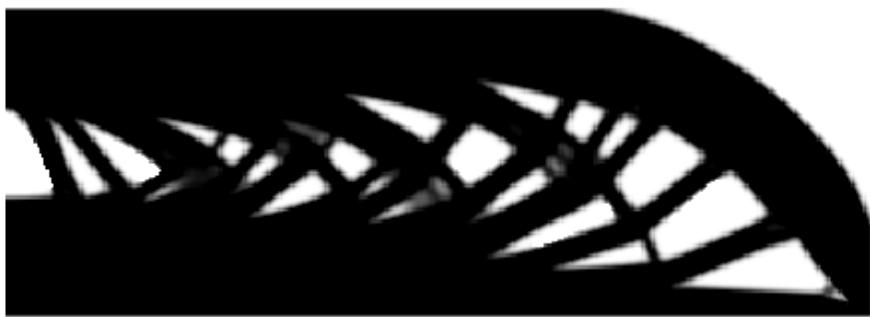


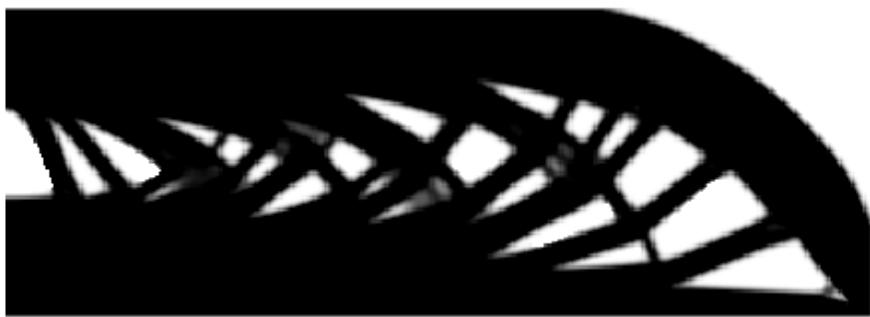


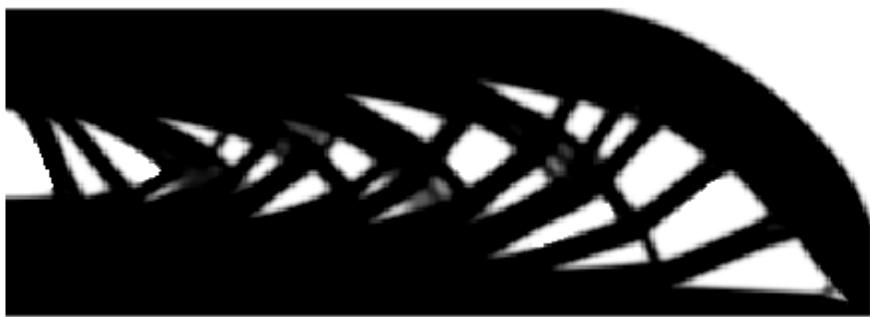


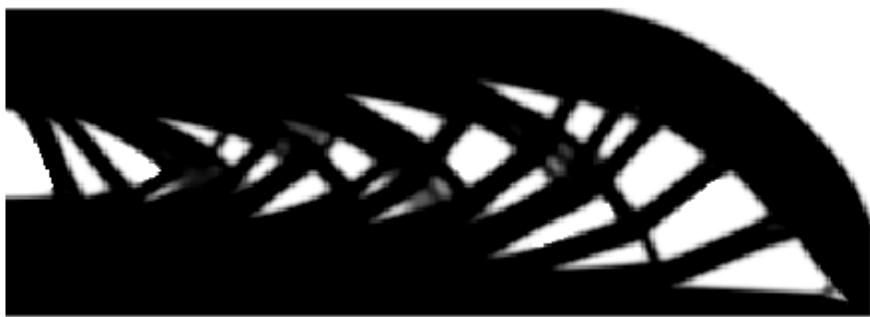


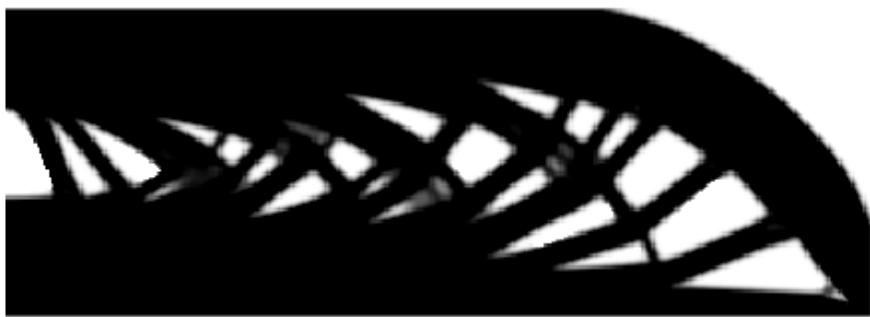


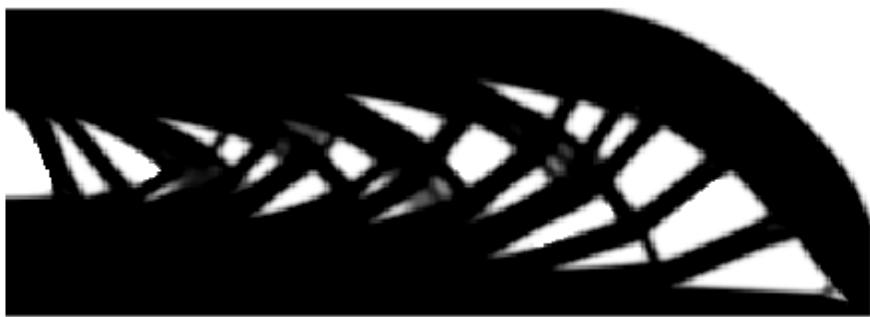


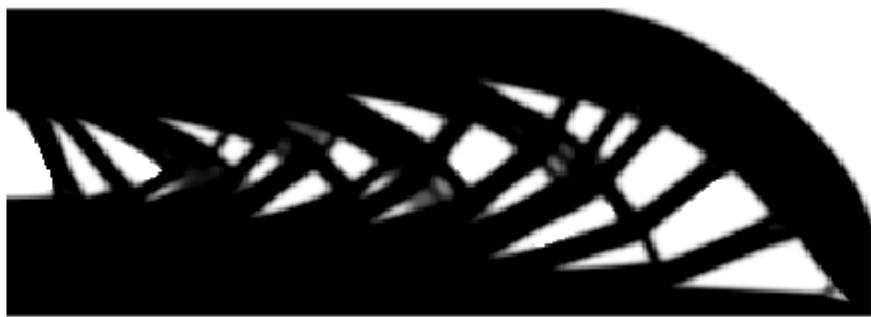


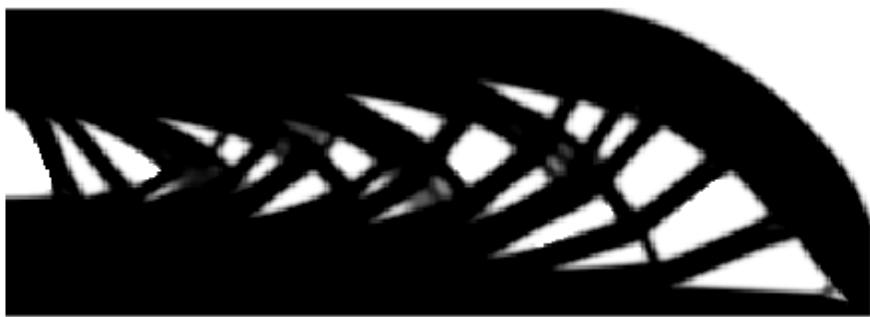


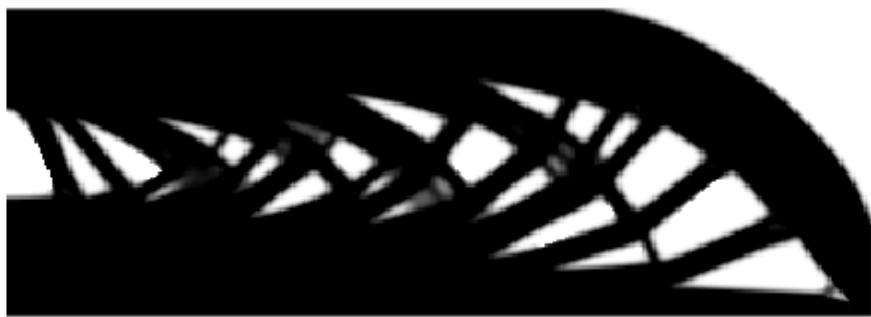


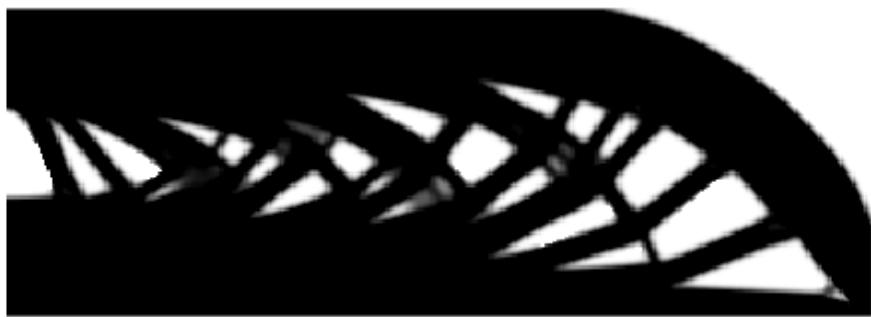


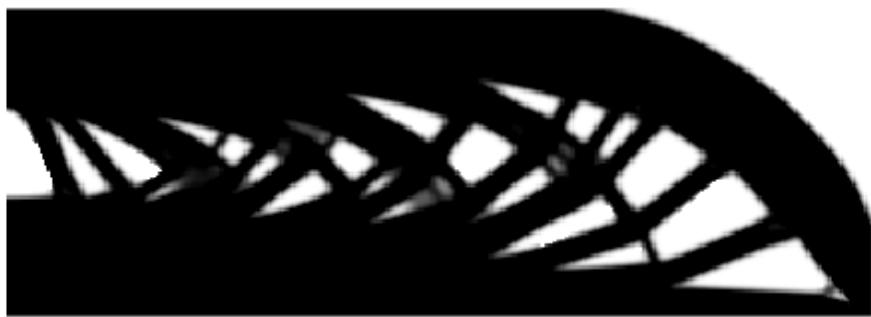


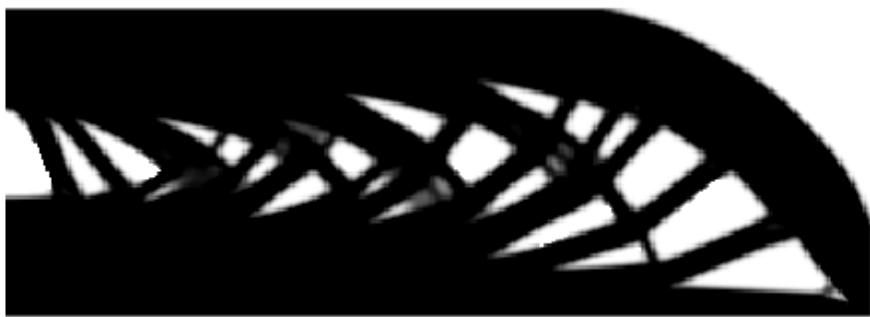


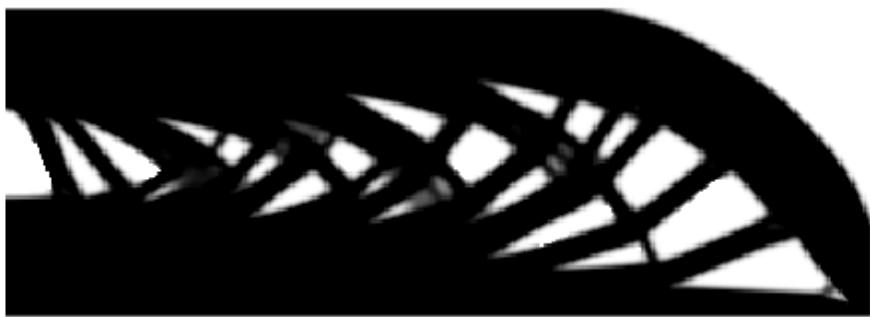


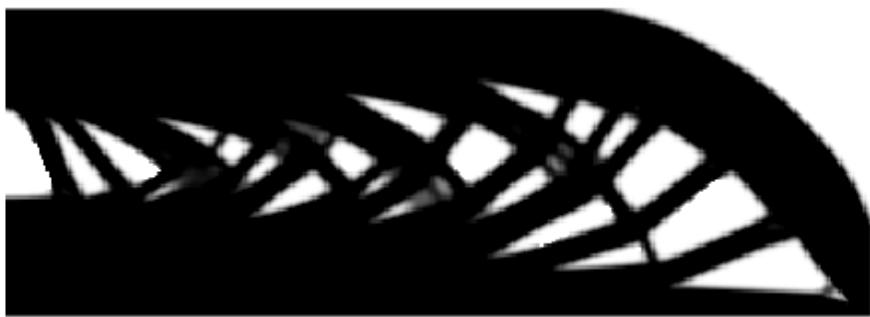


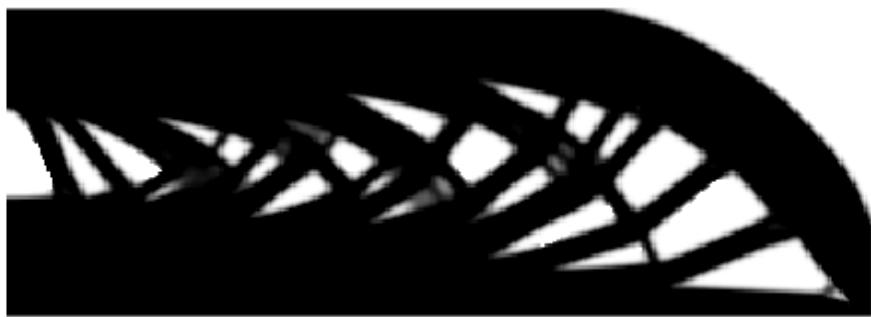


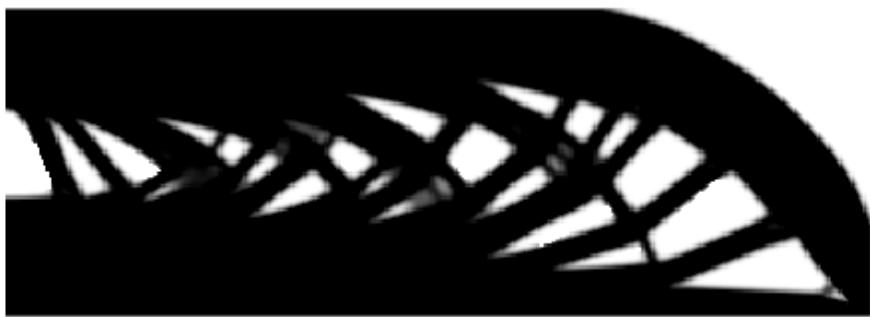


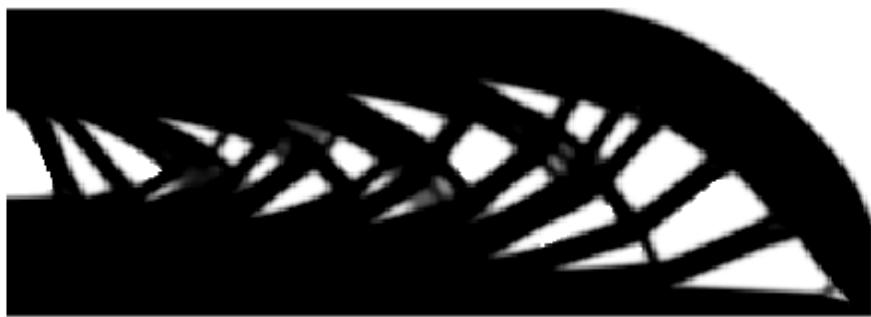


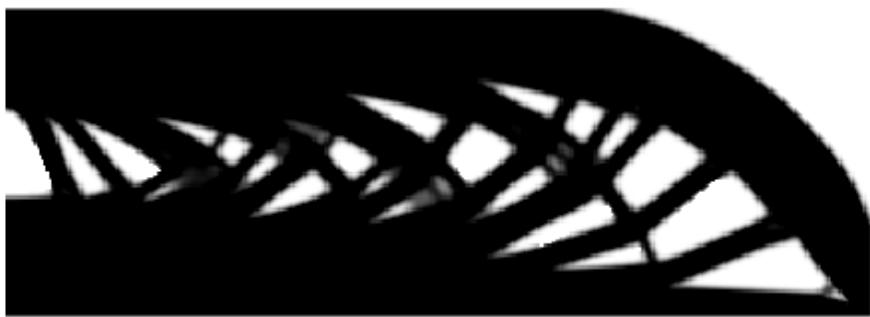


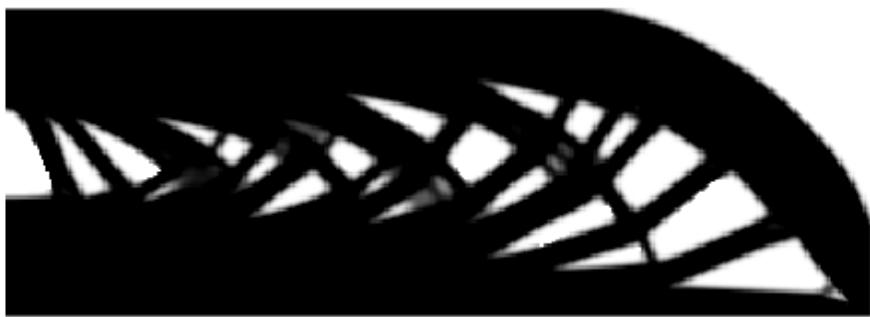


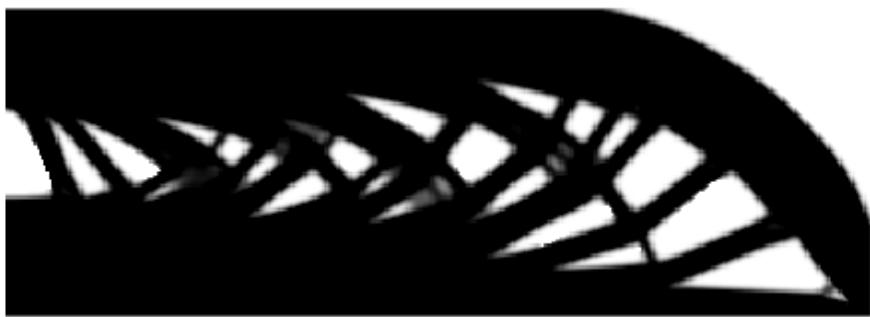


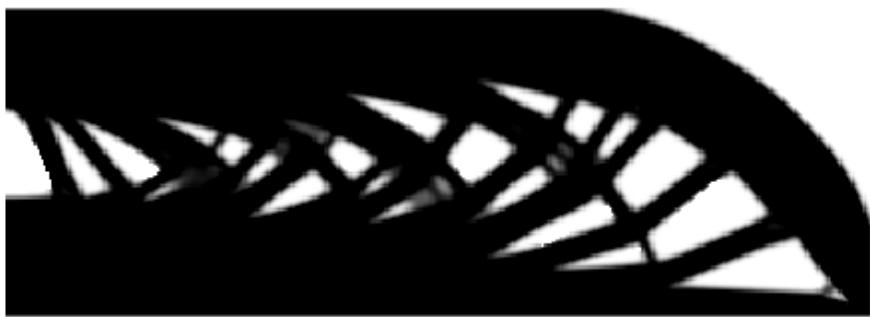


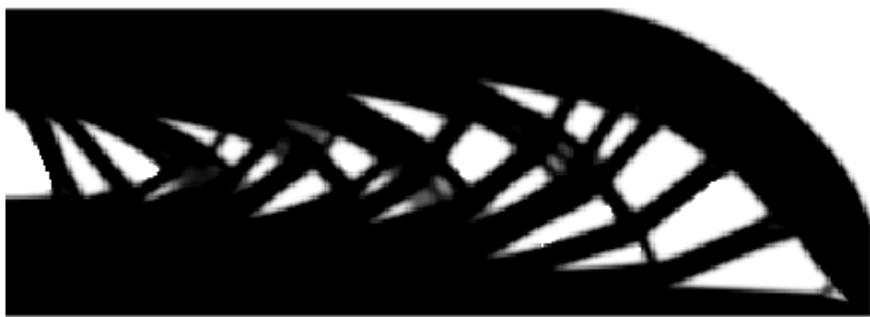


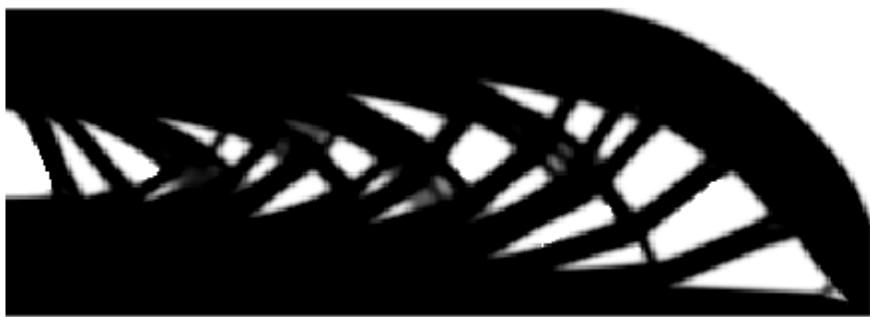


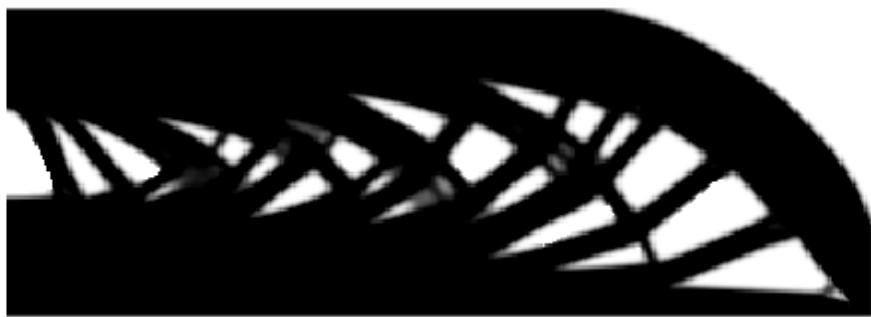


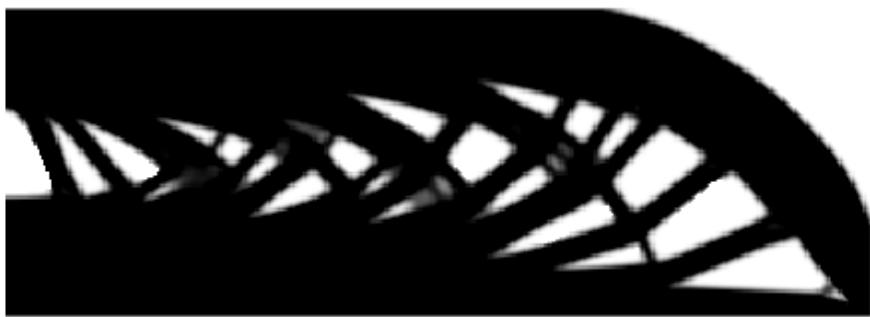


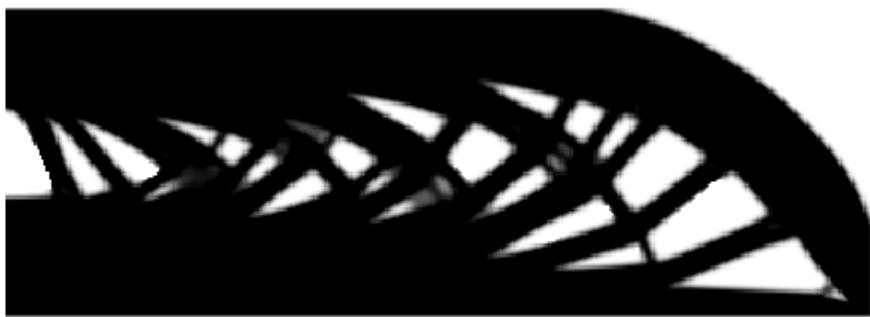


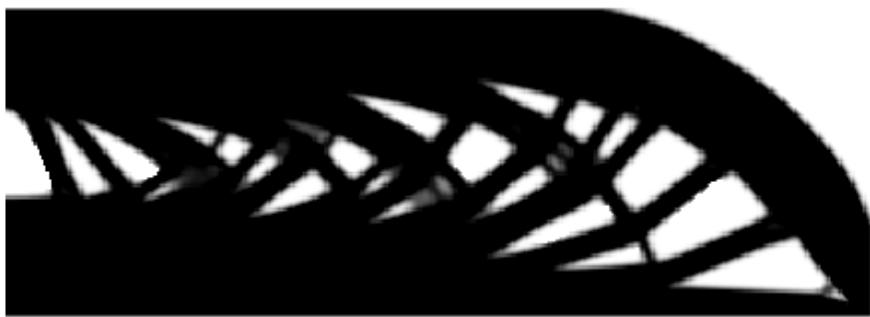


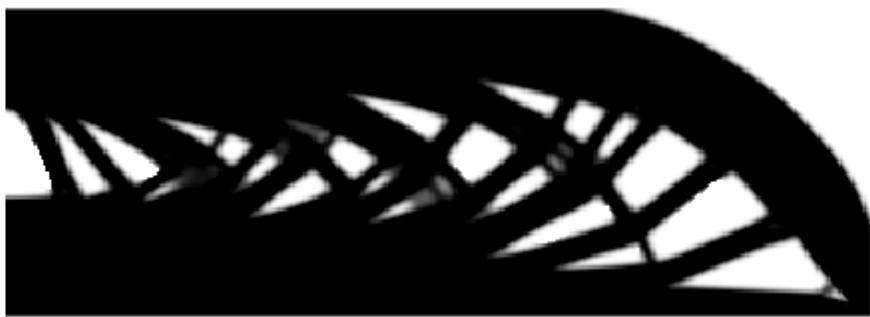


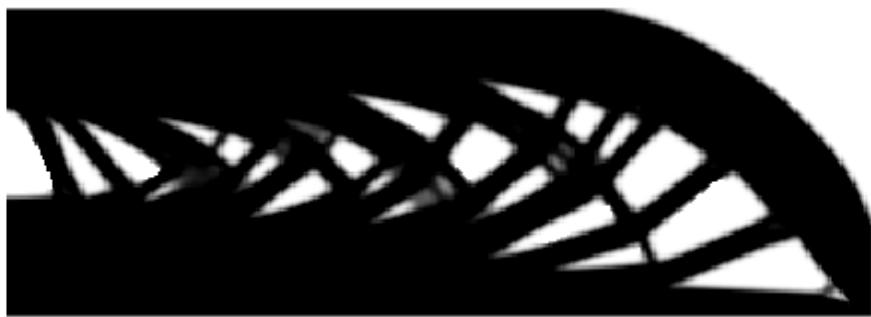


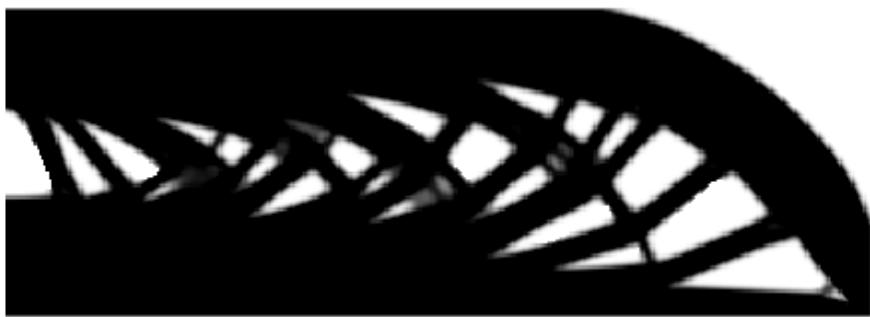


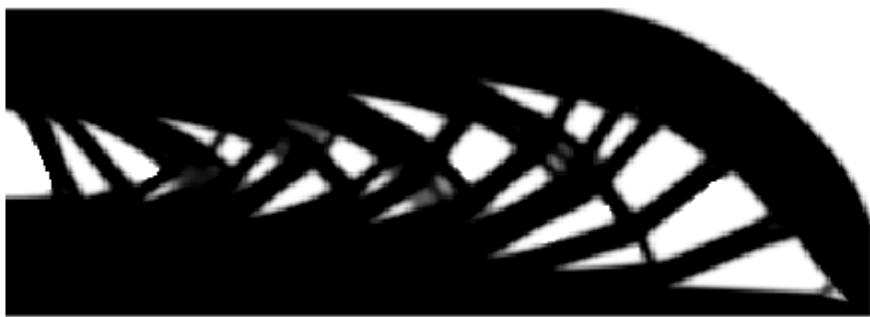


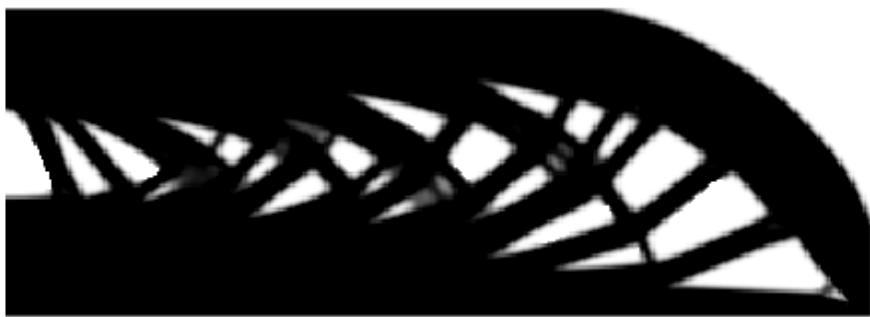


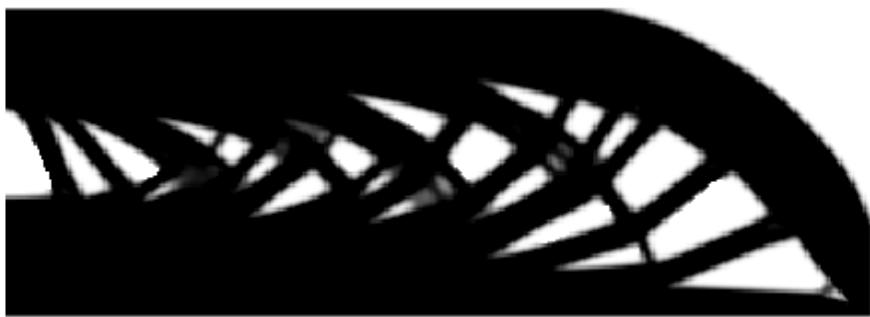


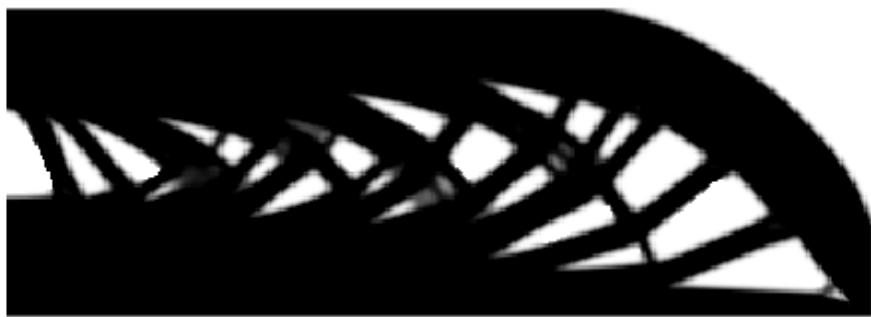


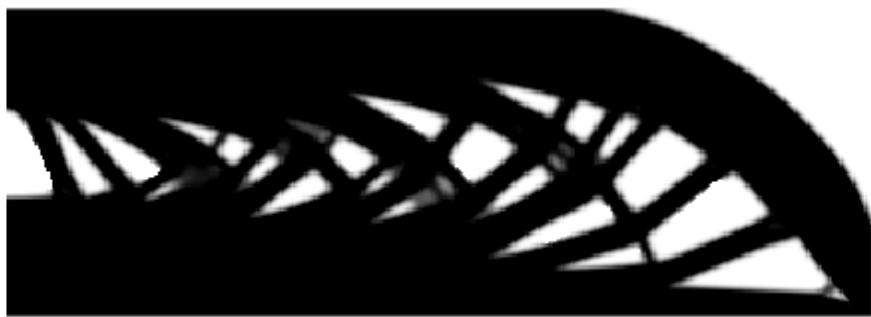


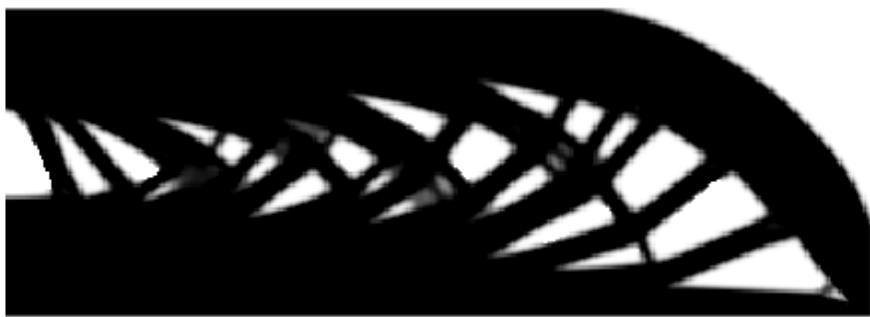


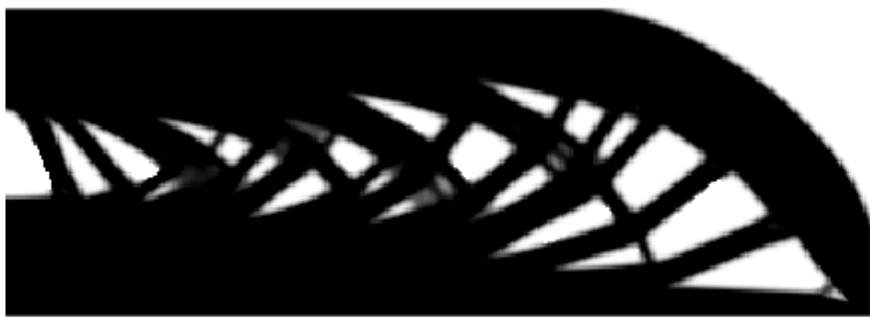


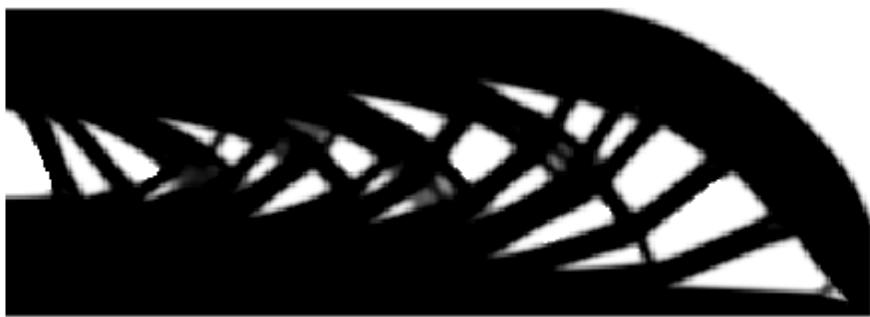


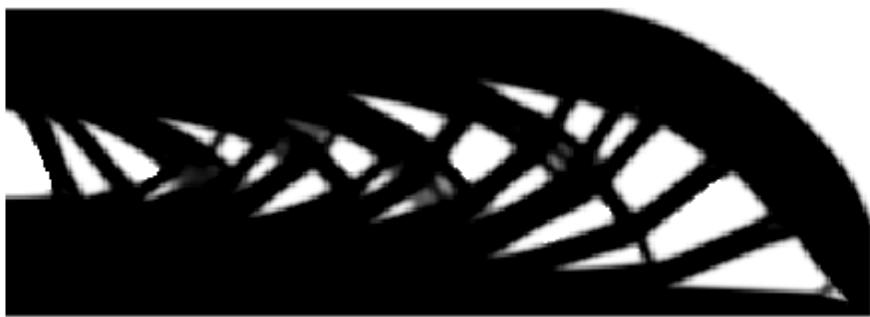


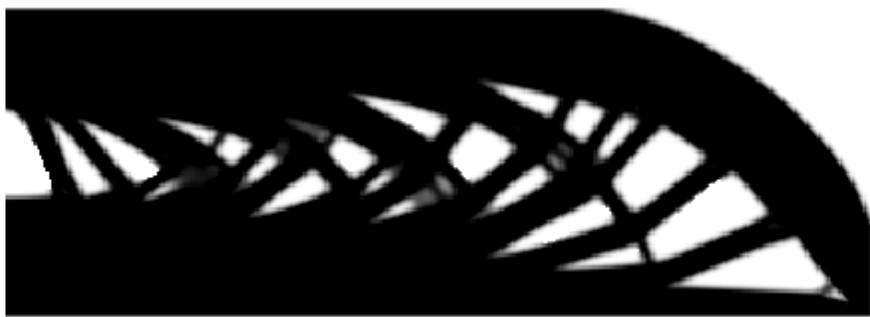


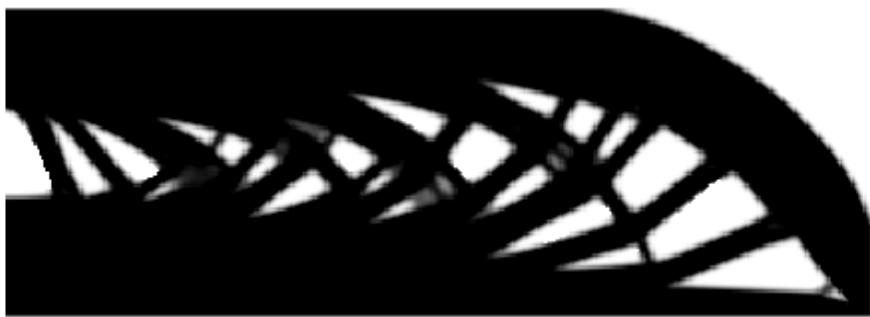


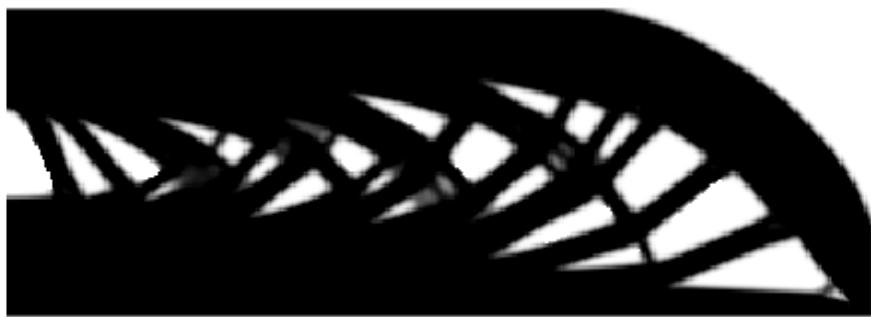


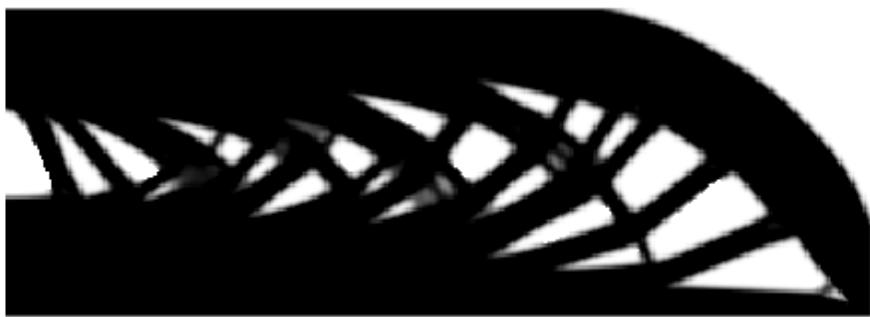


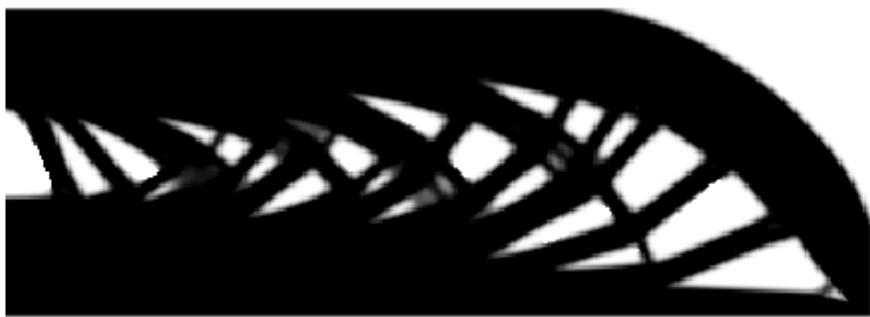


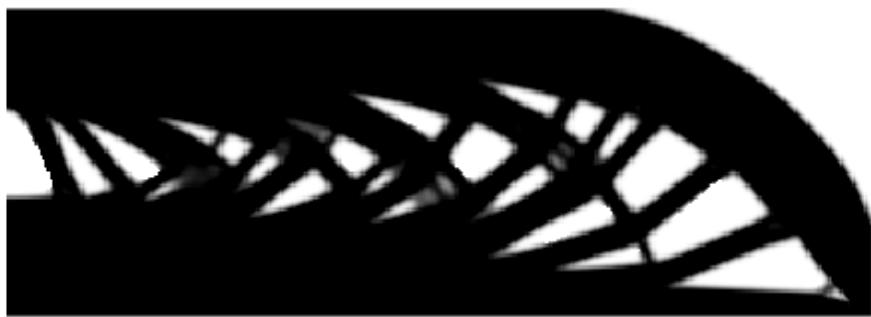


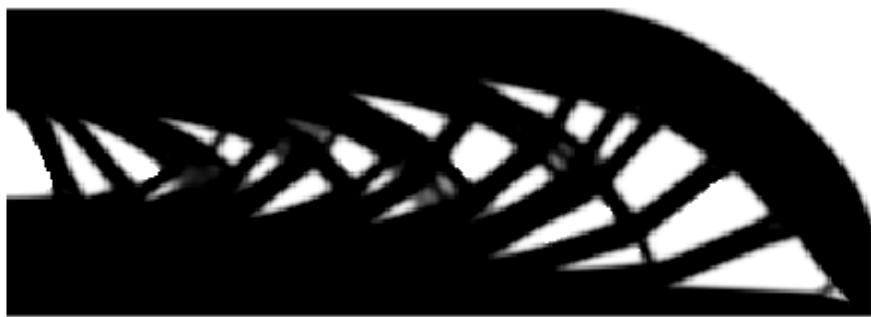


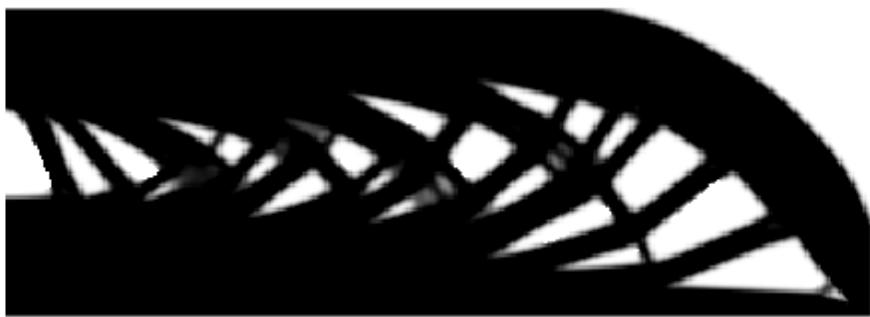


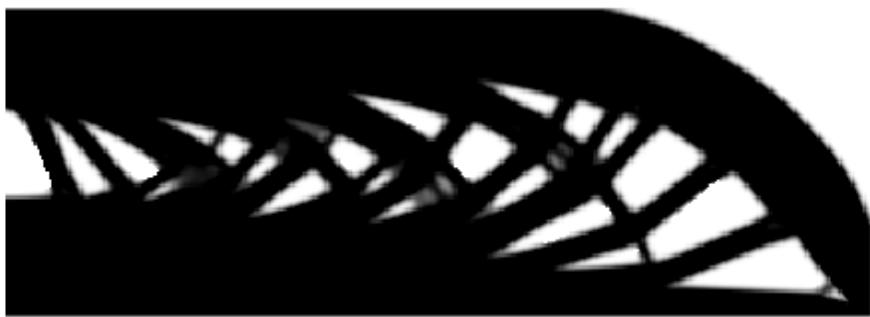


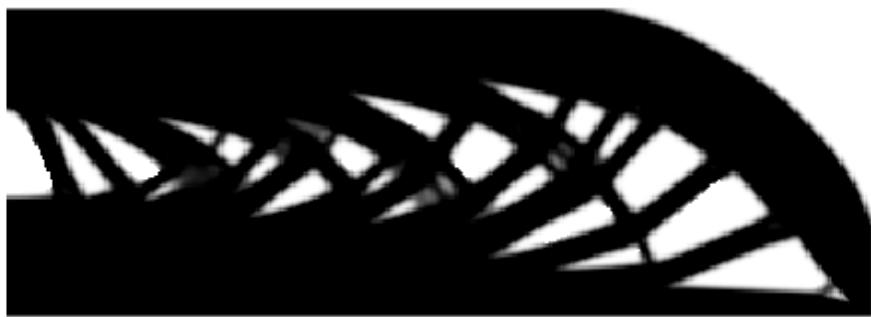


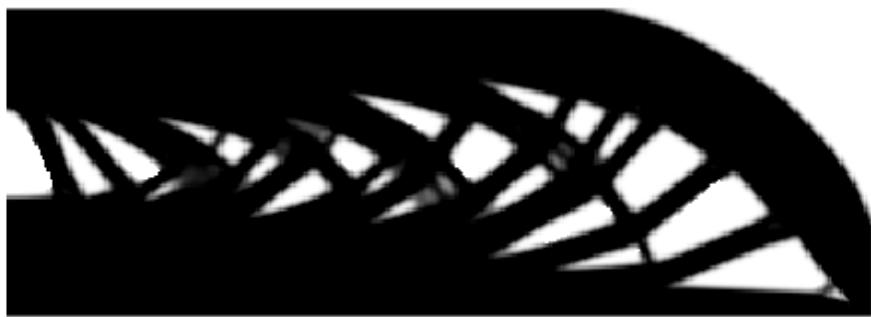


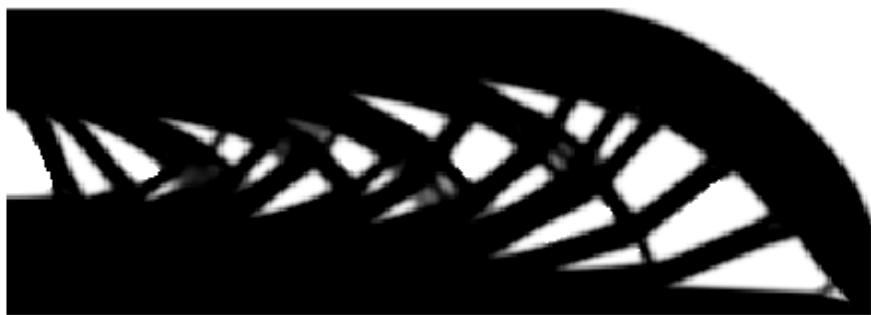


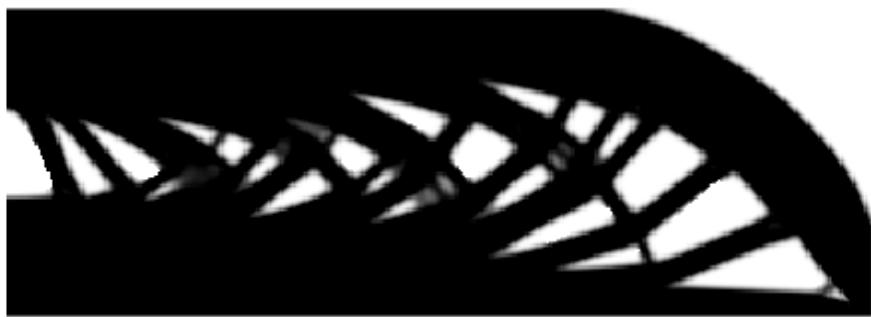


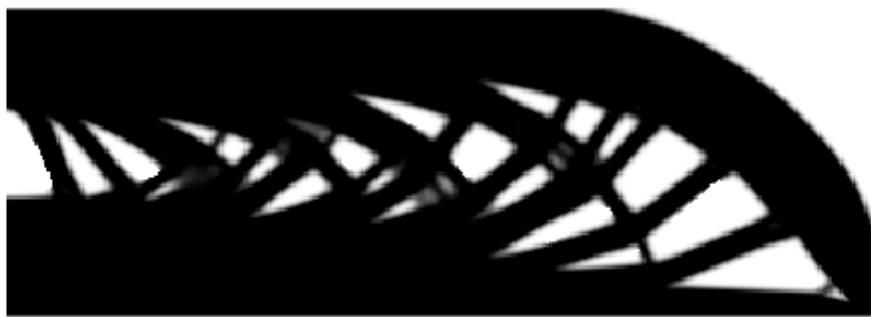


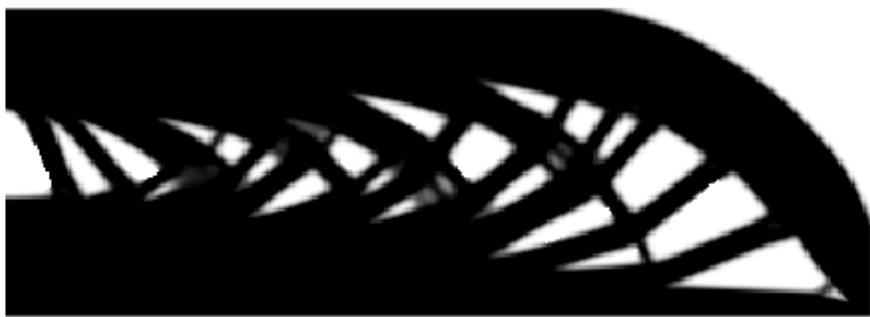


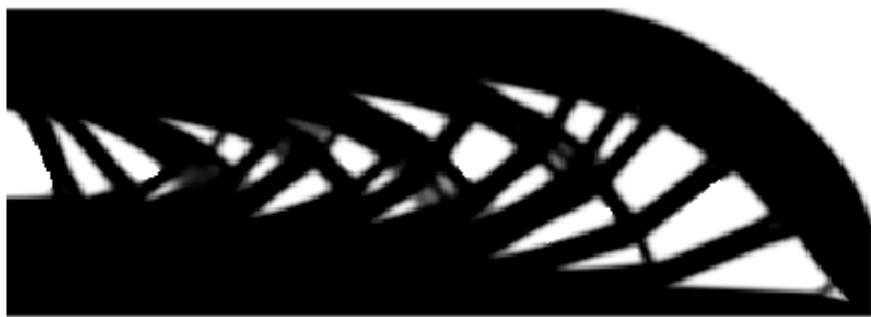


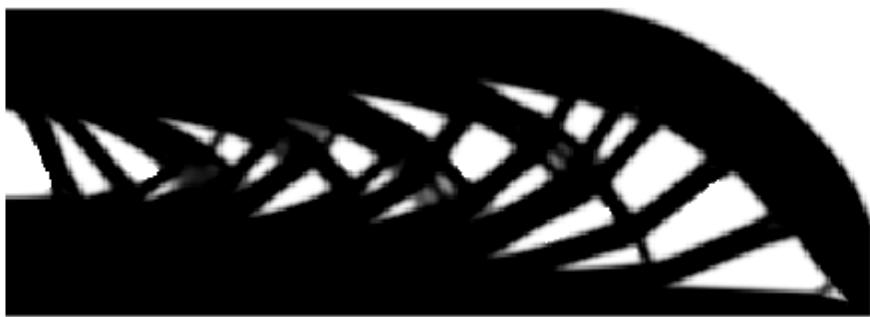


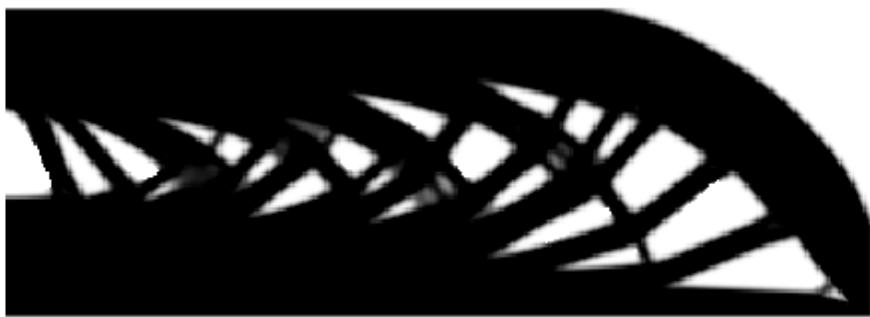


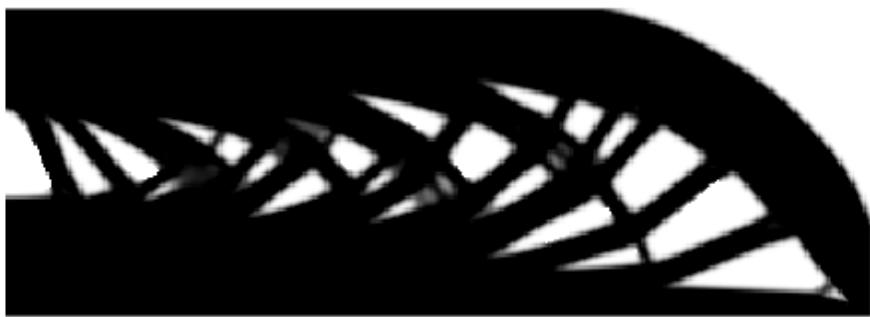


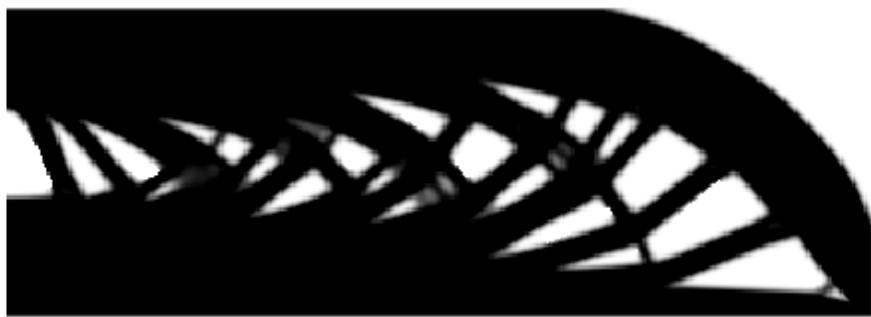


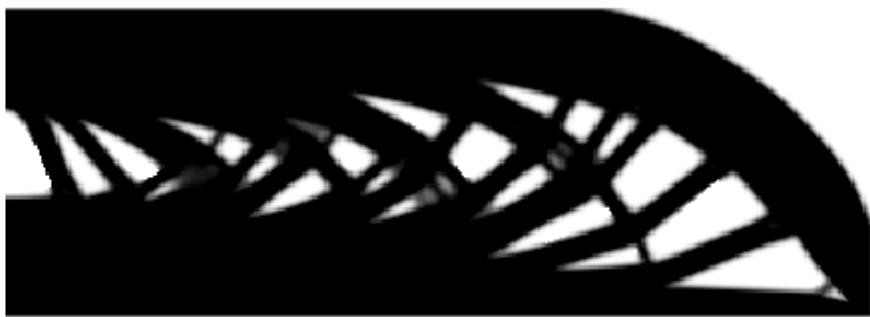


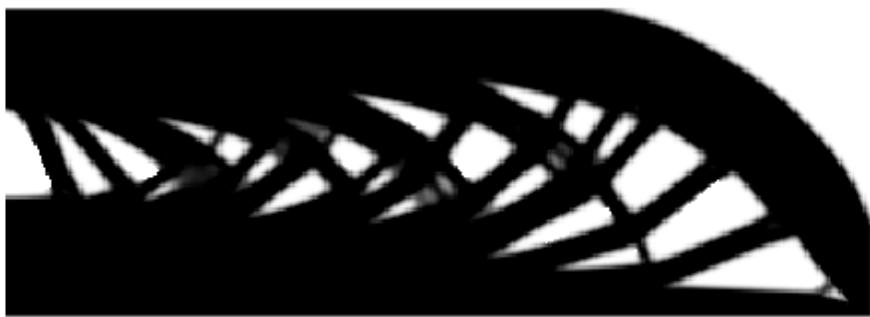


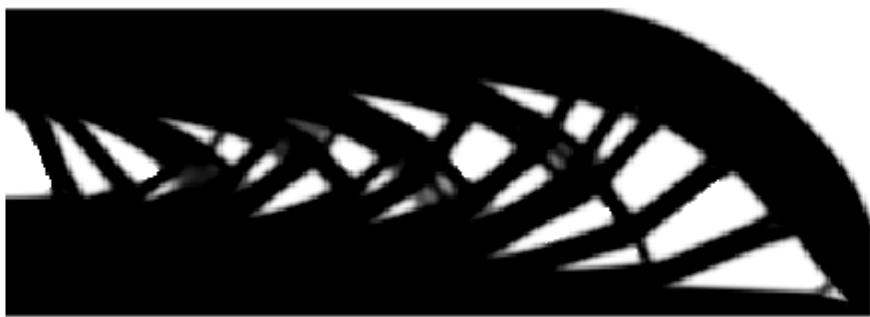


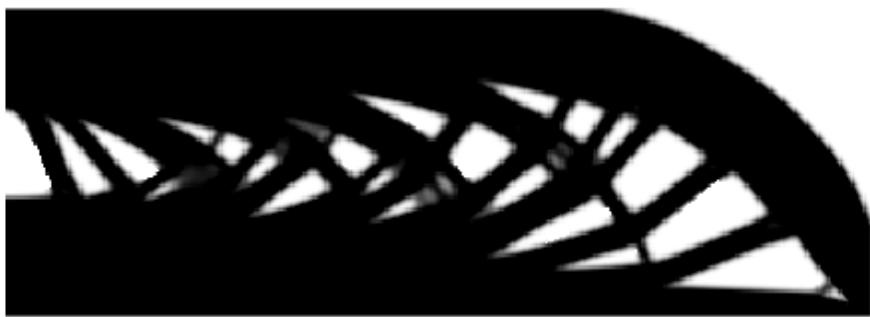


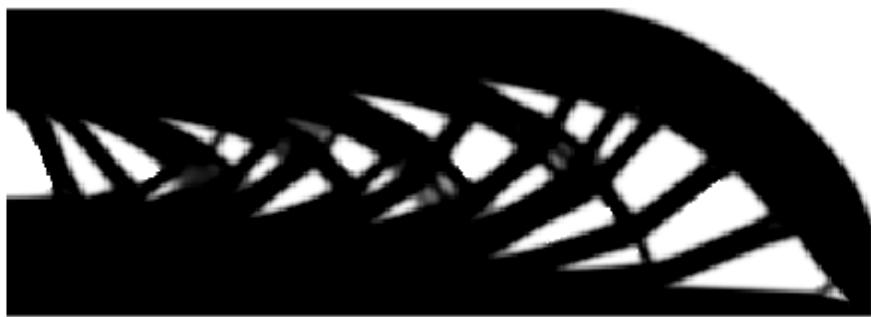


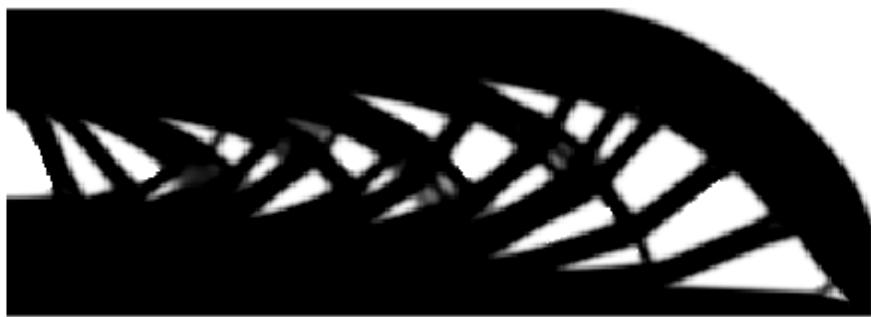


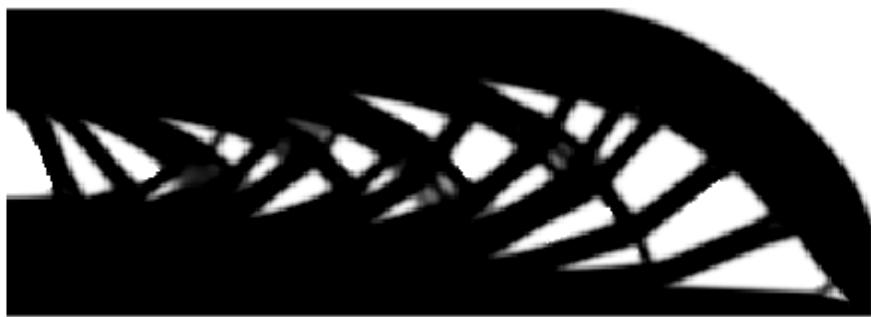


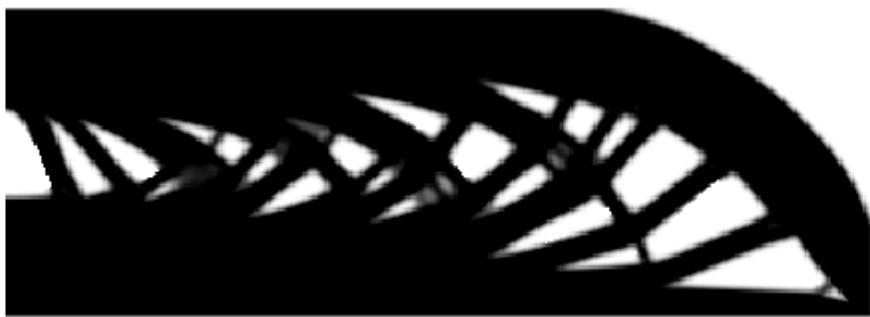


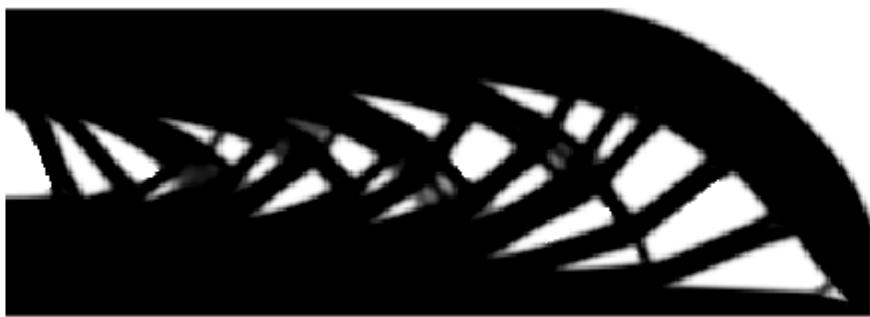


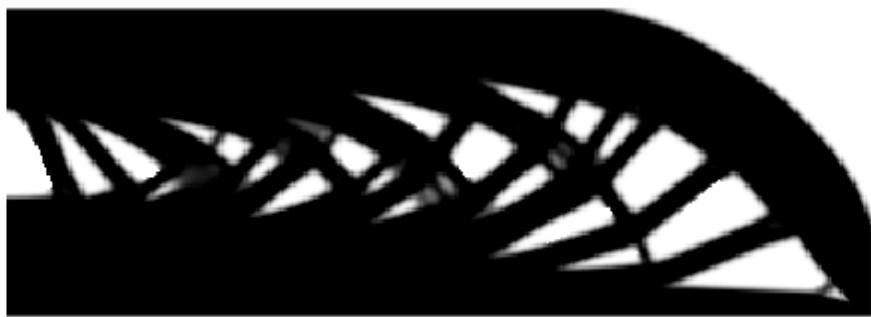


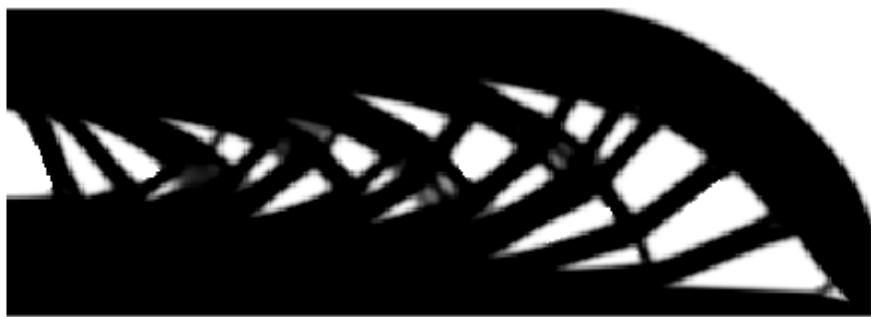


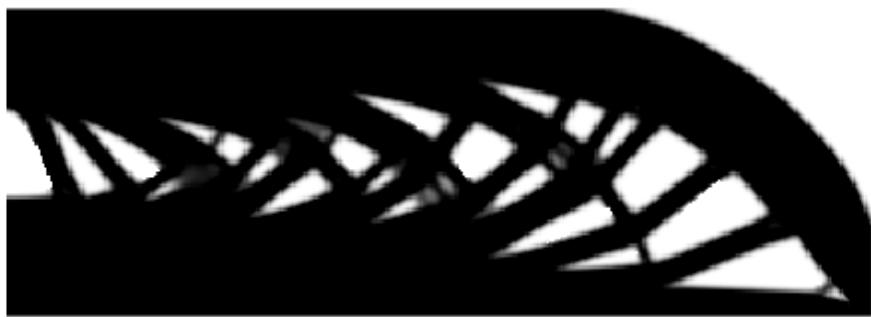


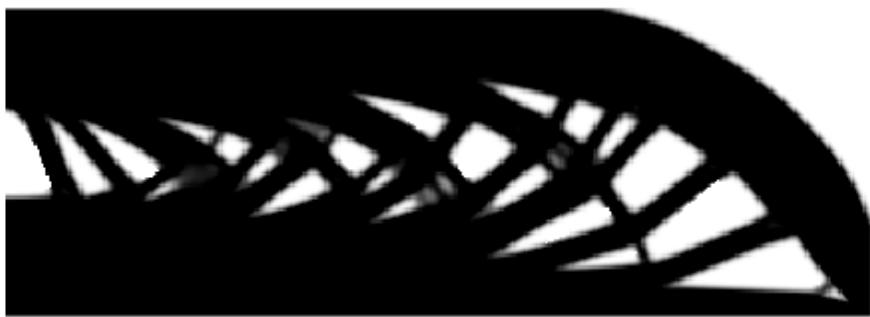


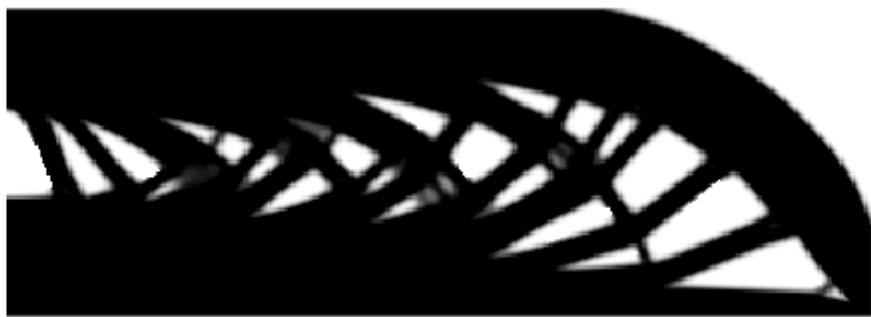


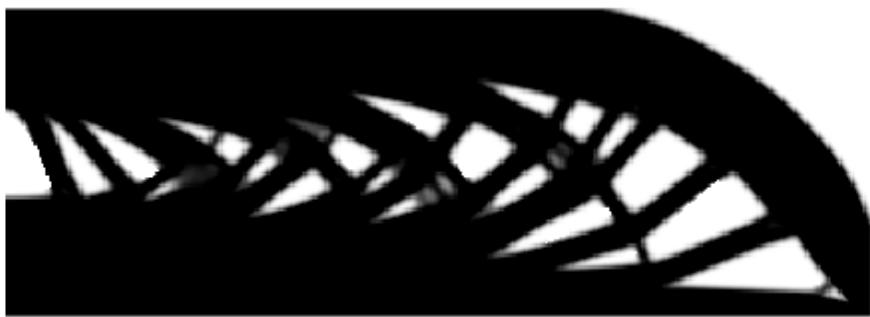


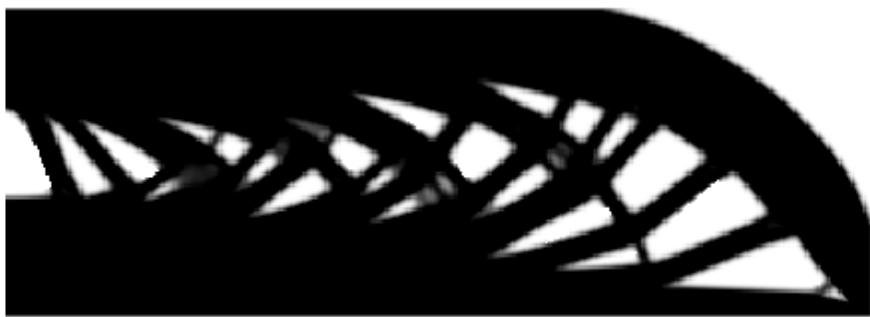


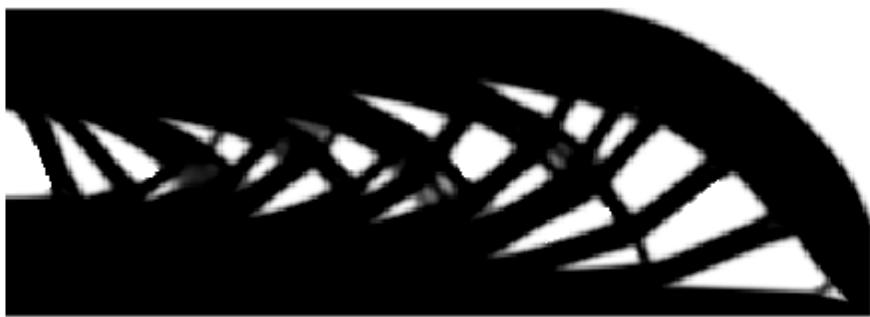


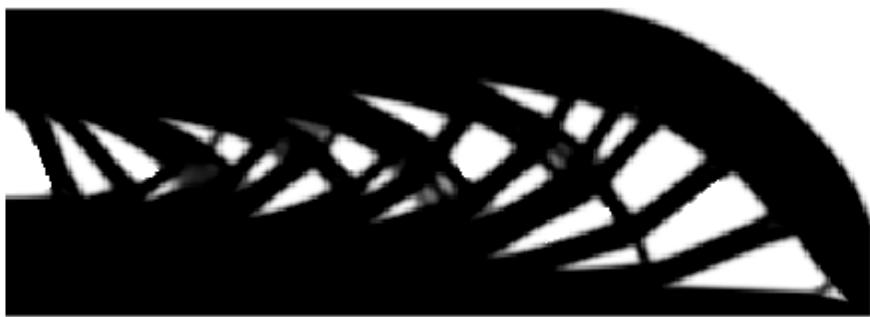


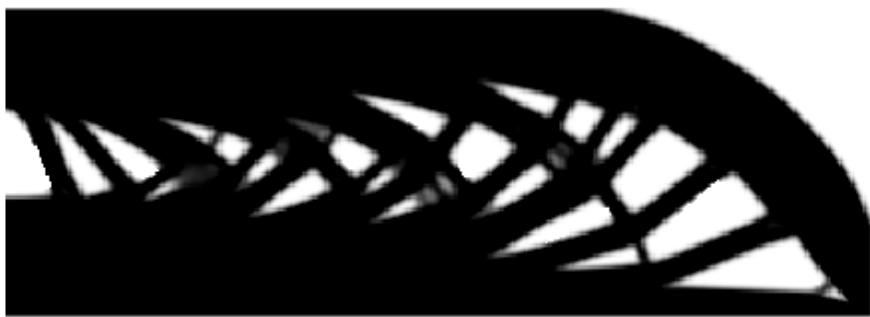


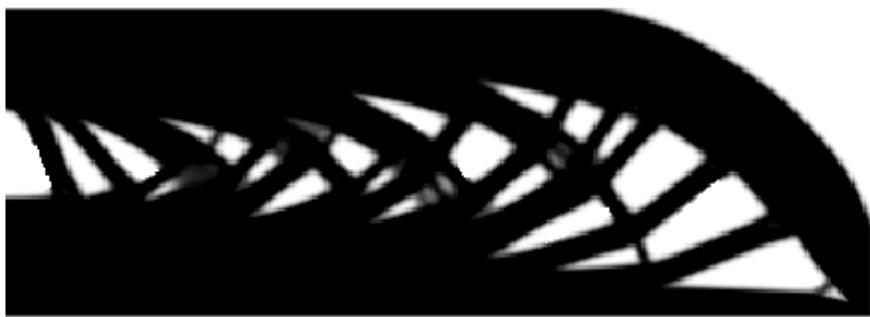


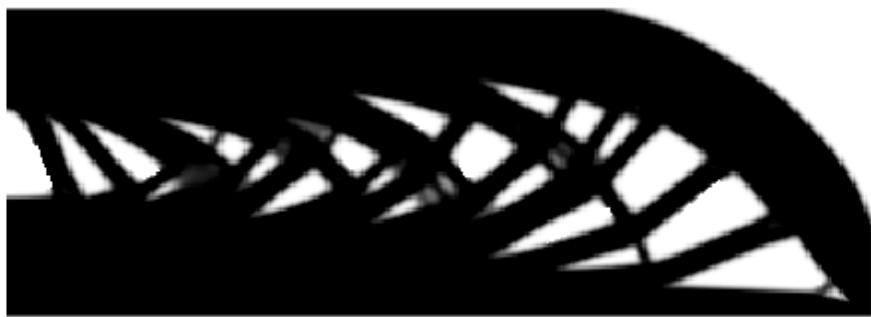


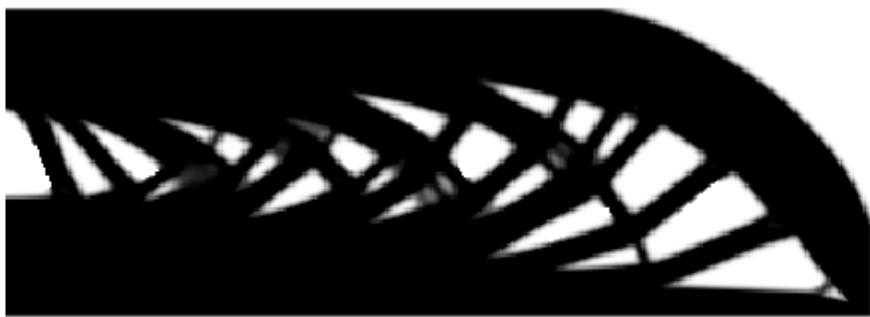


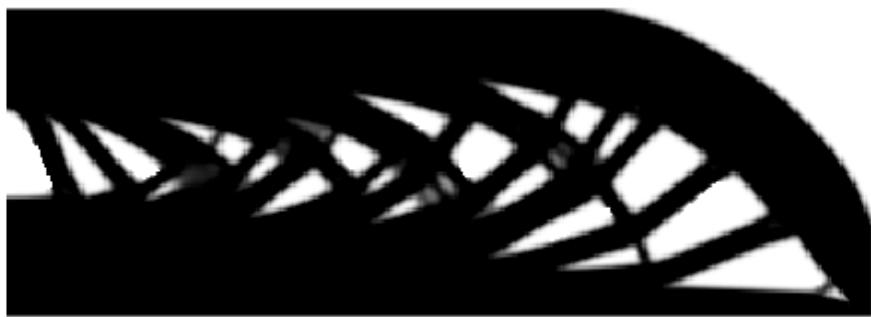


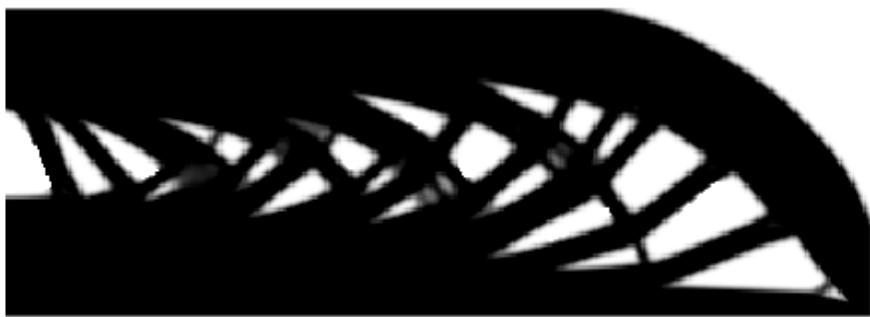


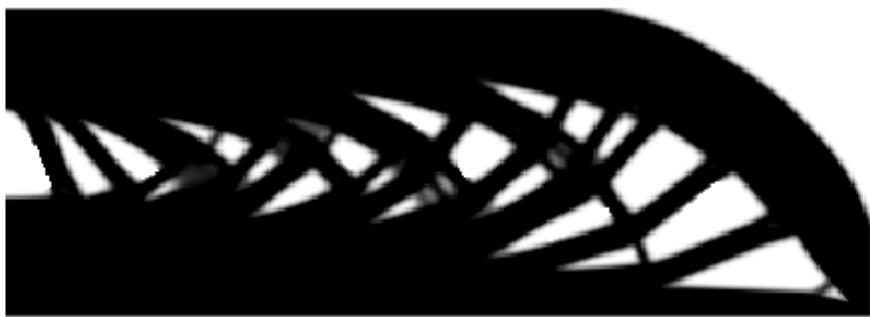


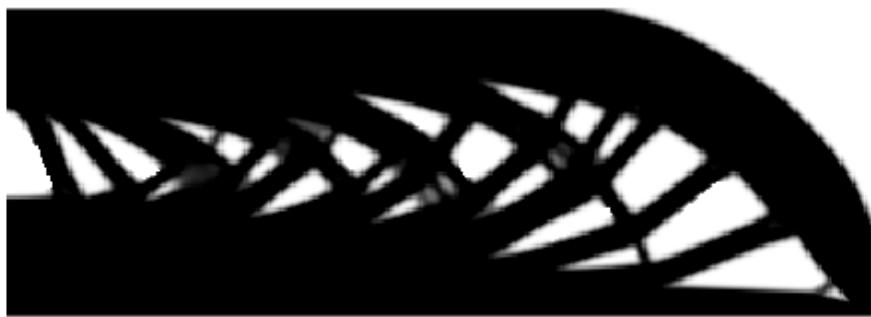


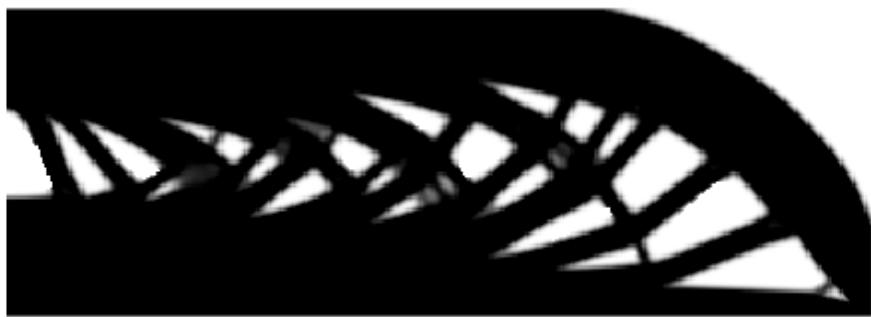


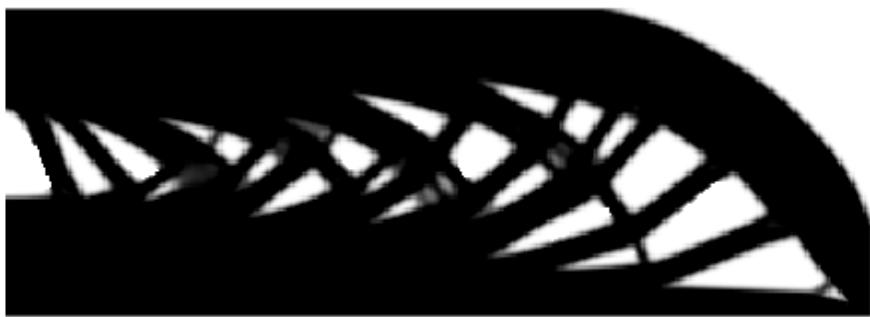


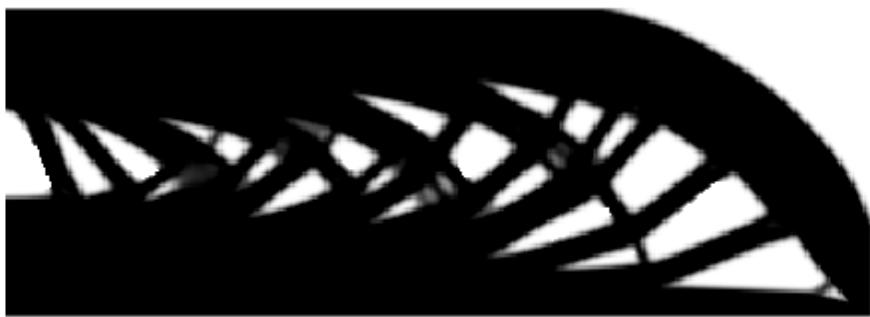


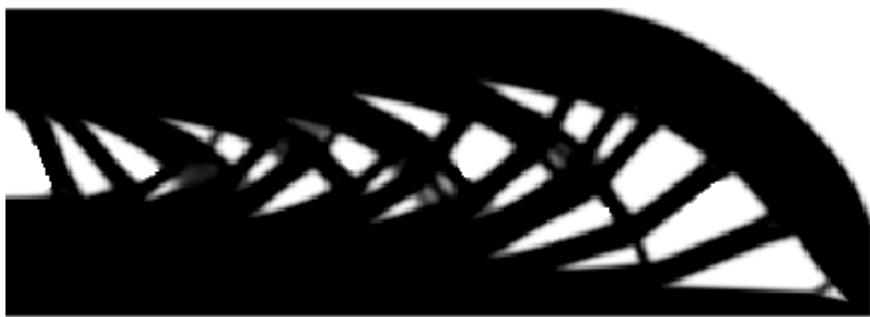


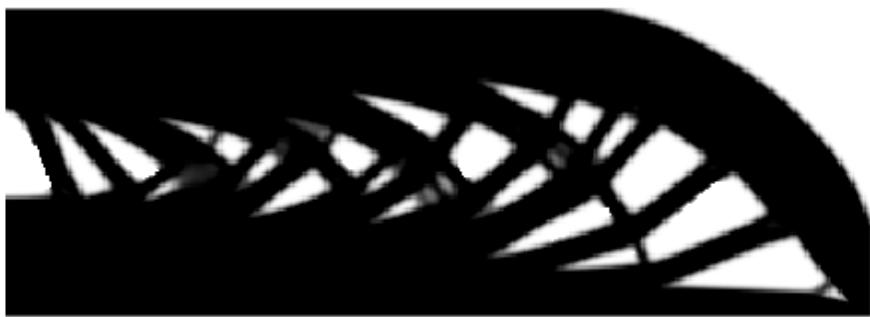


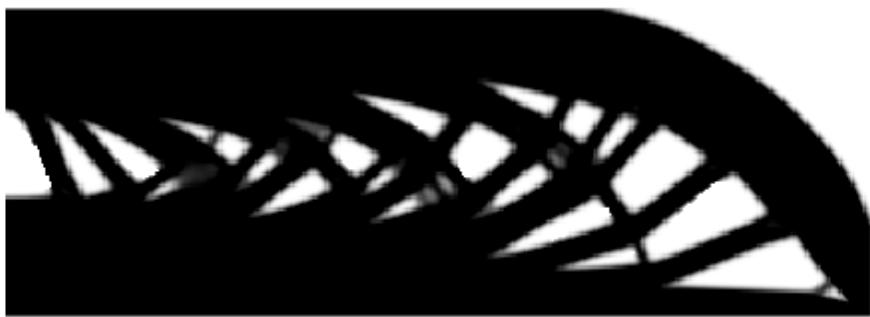


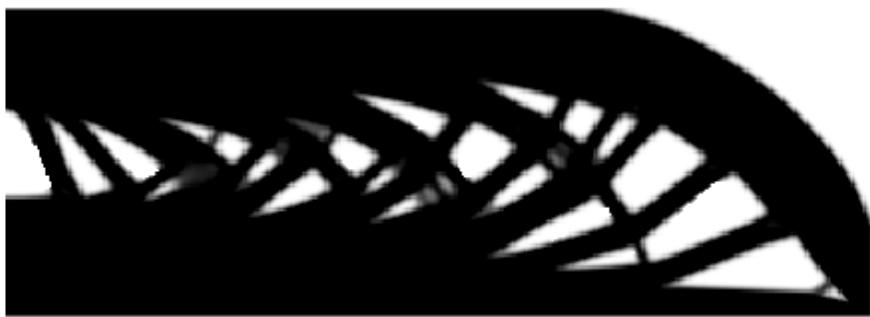


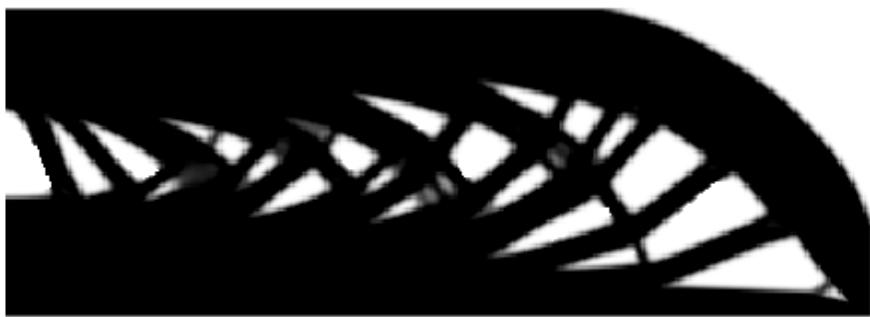




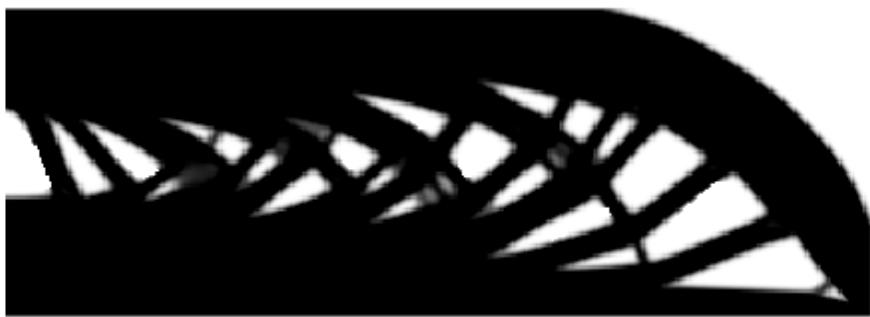


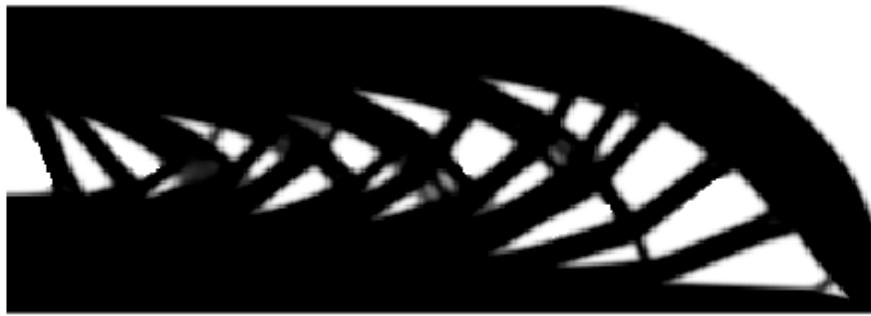












end

