Contents

Image of MBL/NNF Siemens target under dark-field.

This script simulates image of the Siemens test object from the MBL-NNF phase target. We simulate a small region 7umx7um near the center so that the computation can be carried out in reasonable time. Notice the edge artifacts around the edge.

```
clear all;
```

Set parameters of the target.

```
% Following numbers are from Fig 8.2 of the book chapter on MBL/NNF
% target.
Rout=75/2;% Outer radius of siemens star.
Rin=0.6; %Inner radius of siemens star.
RISiO2=1.46;
ThickSiO2=0.09;

PixSize=6.5/100;
wavelength=0.546;
simRadius=7; % radius of simulated region.
```

Compute specimen transmission.

```
xsim=-simRadius:0.02:simRadius;
%2nm sampling is required to properly sample slight over or under-etching of the target
usim=0;
%usim=-1:0.2:1;  % To simulate defocus.

% Assume that the azimuthal wedges are perfectly etched providing exact
% square wave.
ProperEtchProfile=mblnnfSiemens(xsim,xsim,0);
oplProperEtch=(2*pi/wavelength)*(1.33-RISiO2)*ProperEtchProfile*ThickSiO2;
specimenProperEtch=exp(1i*oplProperEtch);

% Assume slight overetching and therefore non-square azimuthal phase
% grating.
OverEtchProfile=mblnnfSiemens(xsim,xsim,0.04);
oplOverEtch=(2*pi/wavelength)*(1.33-RISiO2)*OverEtchProfile*ThickSiO2;
specimenOverEtch=exp(1i*oplOverEtch);
```

Parameters of dark-field microscope.

Parameters correspond to the experimental image that we use in the paper.

```
DFparams.NAo=1;
DFparams.wavelength=wavelength;
DFparams.annulus=[1.1 1.2];
DFparams.nImm=1.515;
DFparams.nEmbb=1.33;

DFsys=microlith(xsim,usim);
DFsys.computesys('Darkfield',DFparams);
```

```matlab
DFImageOverEtch=DFsys.computeimage(specimenOverEtch,'CPU');
DFImageProperEtch=DFsys.computeimage(specimenProperEtch,'CPU');
```

Images and azimuthal profiles at distance of 4um.

Dark regions are etched and white regions are intact silica.

```matlab
rProfile=4;
thetaProfileSim=linspace(-pi/18,pi/18,251);
[xxsim, yysim]=meshgrid(xsim); % Generate spatial grid for resampling along azimuth.

AngularProfileProper=interp2(xxsim,yysim,gray2norm(DFImageProperEtch),...
    rProfile*cos(thetaProfileSim),rProfile*sin(thetaProfileSim));
AngularProfileOver=interp2(xxsim,yysim,gray2norm(DFImageOverEtch),...
    rProfile*cos(thetaProfileSim),rProfile*sin(thetaProfileSim));
AngularProfileProperEtch=interp2(xxsim,yysim,~ProperEtchProfile,...
    rProfile*cos(thetaProfileSim),rProfile*sin(thetaProfileSim),'nearest');
AngularProfileOverEtch=interp2(xxsim,yysim,~OverEtchProfile,...
    rProfile*cos(thetaProfileSim),rProfile*sin(thetaProfileSim),'nearest');

figure(1); clf;

set(1,'color','white','Position',[100 100 800 600],'defaultaxesfontsize',14);
colormap gray;
ha=imagecat(xsim,xsim,~ProperEtchProfile,~OverEtchProfile,DFImageProperEtch,DFImageOverEtch,'equal','link');
% All four images are linked, so zooming or panning one will do the same on
% all others.
axes(ha(1)); title('Properly etched pattern');
axes(ha(2)); title('Over etched pattern (by 4nm)');
axes(ha(3)); title('Dark-field image of properly etched pattern');
axes(ha(4)); title('Dark-field image of over etched pattern');

figure(2); clf;
set(2,'color','white','Position',[100 100 800 600],'defaultaxesfontsize',14);
plot(thetaProfileSim,AngularProfileProper,'r',...
    thetaProfileSim,AngularProfileOver,'g',...
    thetaProfileSim,AngularProfileProperEtch,'k--',...
    thetaProfileSim,AngularProfileOverEtch,'k','LineWidth',2);
legend('Intensity (proper etch)','Intensity (over etch)','Grating profile (proper etch)','Grating profile (over etch)');
title('Azimuthal intensity profile at radius of 4 \mum');
```
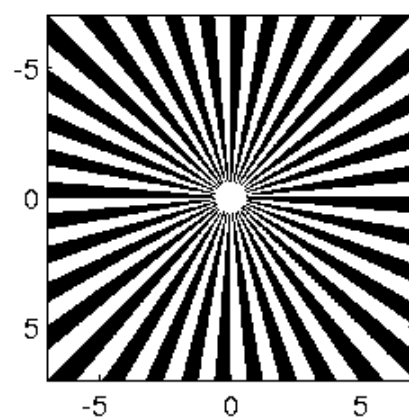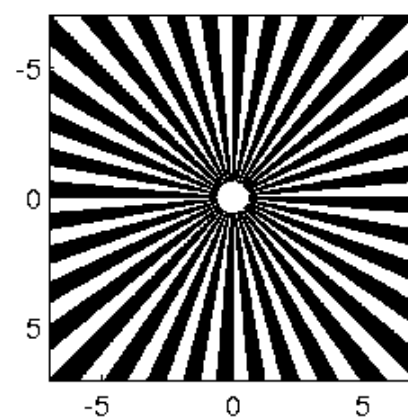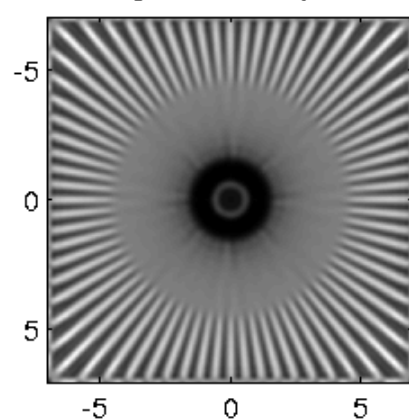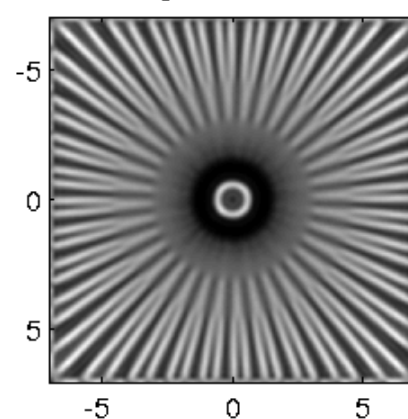
Properly etched pattern

Over etched pattern (by 4nm)

Dark-field image of properly etched pattern

Dark-field image of over etched pattern

Azimuthal intensity profile at radius of 4 μm

- Intensity (proper etch)
- Intensity (over etch)
- Grating profile (proper etch)
- Grating profile (over etch)