PRISMS-Plasticity

Crystal Plasticity

Shear example -BCC Titanium

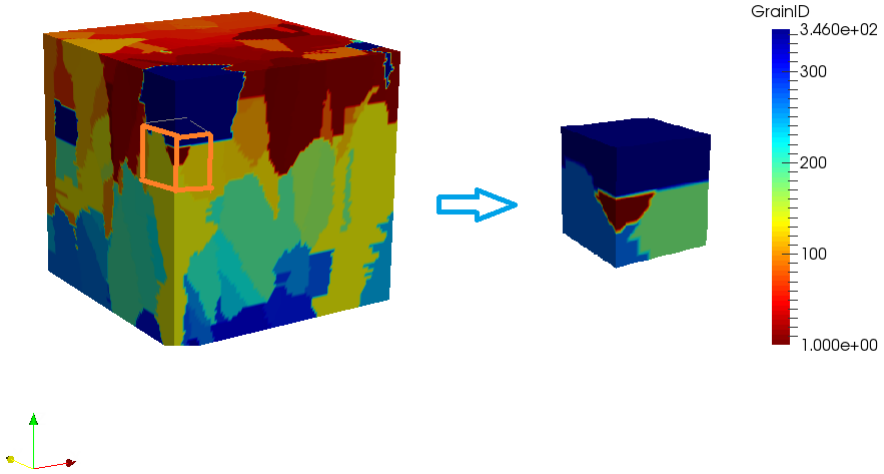

Figure 1: Input microstructure (3D Materials Atlas [2])

This is an illustrative example of a shear deformation problem. A vitrual bcc microstructure was tested with the material parameters of β Ttitanium which were obtained from [1]

Input Crystal Parameters-parameters.h

```
//Elastic Parameters

#define c11 97.7e3 // C11 (MPa)
#define c12 82.7e3 // C12 (MPa)
#define c44 37.5e3 // C44 (MPa)


//Crystal Plasticity parameters

#define numSlipSystems 12 // Chosen the first 12 {110} slip planes
#define latentHardeningRatio 1.4 //q1
#define powerLawExponent 1.0 //a
#define initialSlipResistance 200.0 // CRSS s0(MPa)
#define saturationStress 500.0 //s_s(MPa)
#define initialHardeningModulus 1500.0 //s_s(MPa) //h0(MPa)
```

Input Geometry Parameters

```
// In main.cc crystalPlasticity<dim>::mesh()
double spanX=1.0; //Span along x-axis
double spanY=1.0; //Span along y-axis
double spanZ=1.0; //Span along z-axis


#define feOrder 1 // Basis function interpolation order (1-linear)
#define quadOrder 2 // Quadrature point order n^3 (2->8 quadrature
    points)
#define meshRefineFactor 3 // 2^n*2^n*2^n elements(3->8*8*8 =512
    elements)
#define totalNumIncrements 100 // No. of increments

//In main.cc class BCFunction : public Function<dim>
values[0]=0.001; // displacement along X-Direction per increment


// Read Input Microstructure

unsigned int numPts[3]={20, 20, 22}; // No. of voxels in x,y and z
    directions
```

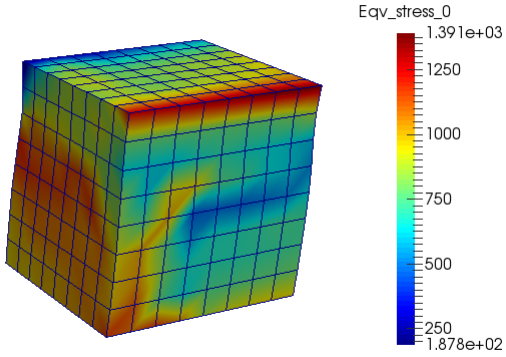

Figure 2: Equivalent Von-Mises Stress shown on a deformation field

References

[1] Lewis, Alexis C., Siddiq M. Qidwai, and Andrew B. Geltmacher. "Slip systems and initiation of plasticity in a body-centered-cubic titanium alloy." Metallurgical and Materials Transactions A 41.10 (2010): 2522-2531.
[2] 3D Materials Atlas AL6XN+Reconstruction

Table 1: BCC Titanium Slip Systems

System Number	Slip Direction	Slip Plane
1	[1 -1 1]	(0 1 1)
2	[1 1 -1]	(0 1 1)
3	[-1 1 1]	(1 0 1)
4	[1 1 -1]	(1 0 1)
5	[-1 1 1]	(1 1 0)
6	[1 -1 1]	(1 1 0)
7	[1 1 1]	(0 -1 1)
8	[-1 1 1]	(0 -1 1)
9	[1 1 1]	(1 0 -1)
10	[1 -1 1]	(1 0 -1)
11	[1 1 1]	(-1 1 0)
12	[1 1 -1]	(-1 1 0)
13	[1 1 -1]	(1 1 2)
14	[1 -1 1]	(-1 1 2)
15	[-1 1 1]	(1 -1 2)
16	[1 1 1]	(1 1 -2)
17	[1 -1 1]	(1 2 1)
18	[1 1 -1]	(-1 2 1)
19	[1 1 1]	(1 -2 1)
20	[-1 1 1]	(1 2 -1)
21	[-1 1 1]	(2 1 1)
22	[1 1 1]	(-2 1 1)
23	[1 1 -1]	(2 -1 1)
24	[1 -1 1]	(2 1 -1)
25	[1 1 -1]	(1 2 3)
26	[1 -1 1]	(-1 2 3)
27	[-1 1 1]	(1 -2 3)
28	[1 1 1]	(1 2 -3)
29	[-1 1 1]	(3 1 2)
30	[1 1 1]	(-3 1 2)
31	[1 1 -1]	(3 -1 2)
32	[1 -1 1]	(3 1 -2)
33	[1 -1 1]	(2 3 1)
34	[1 1 -1]	(-2 3 1)
35	[1 1 1]	(2 -3 1)
36	[-1 1 1]	(2 3 -1)
37	[1 -1 1]	(1 3 2)
38	[1 1 -1]	(-1 3 2)
39	[1 1 1]	(1 -3 2)
40	[-1 1 1]	(1 3 -2)
41	[1 1 -1]	(2 1 3)
42	[1 -1 1]	(-2 1 3)
43	[-1 1 1]	(2 -1 3)
44	[1 1 1]	(2 1 -3)
45	[-1 1 1]	(3 2 1)
46	[1 1 1]	(-3 2 1)
47	[1 1 -1]	(3 -2 1)
48	[1 -1 1]	(3 2 -1)