PRISMS-Plasticity

Crystal Plasticity

Shear example -HCP AZ31 Mg alloy

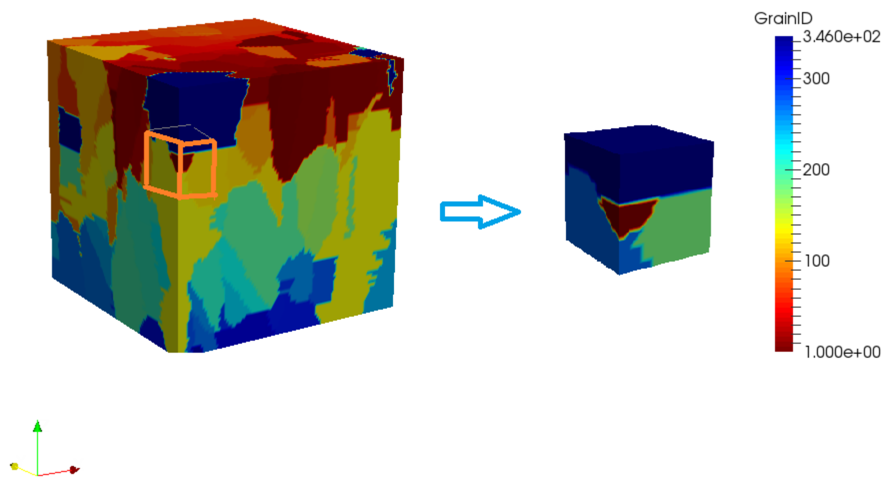

Figure 1: Input microstructure (3D Materials Atlas [2])

This is an illustrative example of a shear deformation problem. A vitrual hcp microstructure was tested with the material parameters of AZ31 Mg alloy which were obtained from [1]

Input Crystal Parameters-parameters.h

```
//Elastic Parameters

#define c11 59.3e3 // C11 (MPa)
#define c12 25.7e3 // C12 (MPa)
#define c13 21.4e3 // C44 (MPa)
#define c33 61.5e3 // C33 (MPa)
#define c44 16.4e3 // C44 (MPa)



//Crystal Plasticity parameters

#define numSlipSystems 18 // No. of slip systems
#define numTwinSystems 6 // No. of twin systems
#define latentHardeningRatio 1.4 //q1
#define powerLawExponent1 1.1 //a_basal
#define powerLawExponent2 0.8 //a_prismatic
```

```
#define powerLawExponent3 0.8 //a_pyramidal<a>
#define powerLawExponent4 0.8 //a_pyramidal<c+a>
#define powerLawExponent5 1.1 //a_twin<c+a>
#define initialSlipResistance1 25.0 // CRSS s0_basal(MPa)
#define initialSlipResistance2 68.0 // CRSS s0_prismatic(MPa)
#define initialSlipResistance3 68.0 // CRSS s0_pyramidal<a>(MPa)
#define initialSlipResistance4 68.0 // CRSS s0_pyramidal<c+a>(MPa)
#define initialSlipResistance5 40.0 // CRSS s0_twin<c+a>(MPa)
#define saturationStress1 70.0 //s_s_basal(MPa)
#define saturationStress2 210.0 //s_s_prismatic(MPa)
#define saturationStress3 210.0 //s_s_pyramidal<a>(MPa)
#define saturationStress4 210.0 //s_s_pyramidal<c+a>(MPa)
#define saturationStress5 50.0 //s_s_twin<c+a>(MPa)
#define initialHardeningModulus1 100.0 //h0_basal(MPa)
#define initialHardeningModulus2 130.0 //h0_prismatic(MPa)
#define initialHardeningModulus3 130.0 //h0_pyramidal<a>(MPa)
#define initialHardeningModulus4 130.0 //h0_pyramidal<c+a>(MPa)
#define initialHardeningModulus5 50.0 //h0_twin<c+a>(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
```

References

[1] Choi, S-H., et al. "Simulation of stress concentration in Mg alloys using the crystal plasticity finite element method." Acta Materialia 58.1 (2010): 320-329.

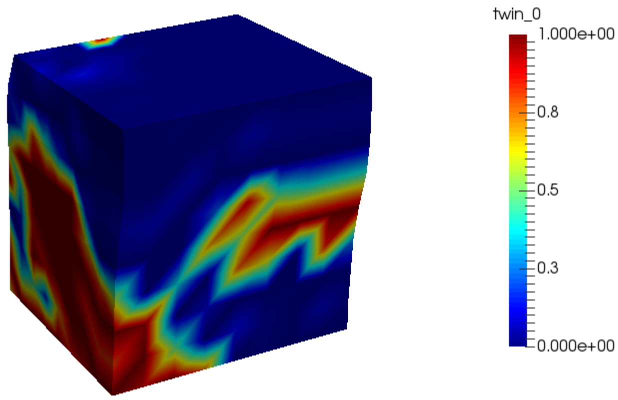

Figure 2: Twinned region(0-no twin, 1-twin) shown on a deformation field

[2] 3D Materials Atlas AL6XN+Reconstruction

Table 1: HCP Magnesium Slip Systems

System Number	Slip Direction	Slip Plane
1	[1 1 -2 0]	(0 0 0 1)
2	[-2 1 1 0]	(0 0 0 1)
3	[1 -2 1 0]	(0 0 0 1)
4	[1 -2 1 0]	(1 0 -1 0)
5	[2 -1 -1 0]	(0 1 -1 0)
6	[1 1 -2 0]	(-1 1 0 0)
7	[1 -2 1 0]	(1 0 -1 1)
8	[-2 1 1 0]	(0 1 -1 1)
9	[-1 -1 2 0]	(-1 1 0 1)
10	[-1 2 -1 0]	(-1 0 1 1)
11	[2 -1 -1 0]	(0 -1 1 1)
12	[1 1 -2 0]	(1 -1 0 1)
13	[-1 -1 2 3]	(1 1 -2 2)
14	[1 -2 1 3]	(-1 2 -1 2)
15	[2 -1 -1 3]	(-2 1 1 2)
16	[1 1 -2 3]	(-1 -1 2 2)
17	[-1 2 -1 3]	(1 -2 1 2)
18	[-2 1 1 3]	(2 -1 -1 2)
19	[-1 0 1 1]	(1 0 -1 2)
20	[1 0 -1 1]	(-1 0 1 2)
21	[-1 1 0 1]	(1 -1 0 2)
22	[1 -1 0 1]	(-1 1 0 2)
23	[0 -1 1 1 1]	(0 1 -1 2)
24	[0 1 -1 1]	(0 -1 1 2)