Composite_Micromechanics

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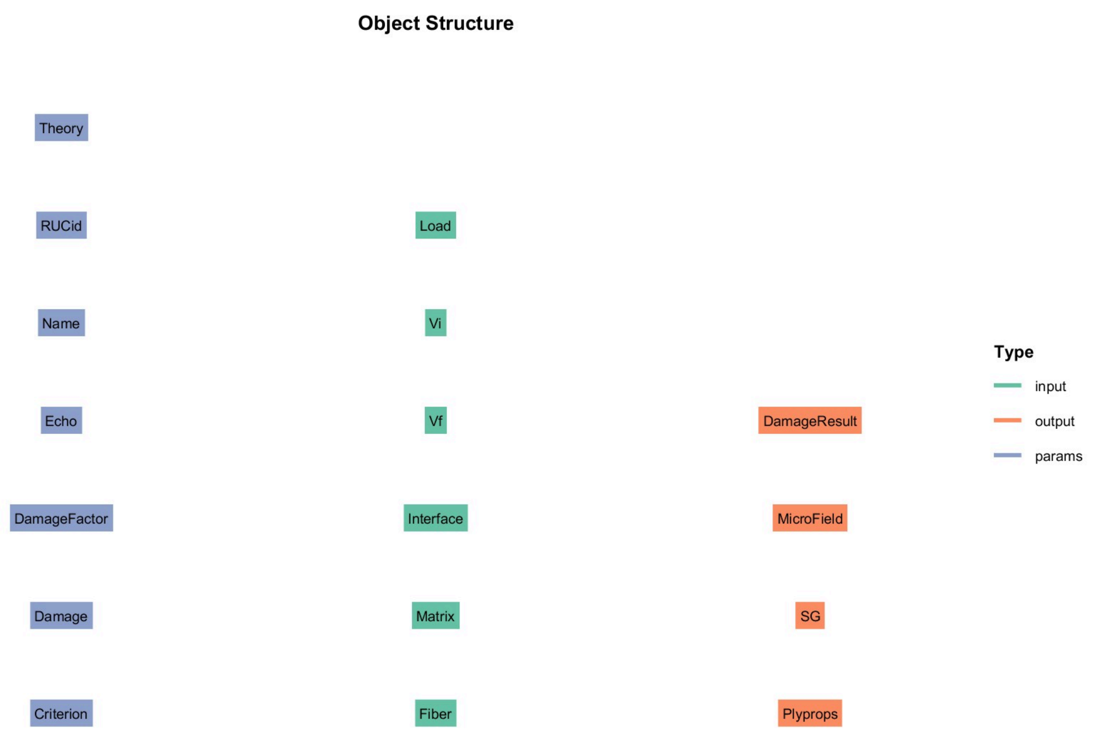
1 介绍

Composite_Micromechanics 类主要用来分析复合材料的微观力学行为，运算方法来自于Practical-Micromechanics，这是一个比较专业的微观复合材料分析工具，部分复合材料的宏观预测属性跟实际数据相差很少。

本意是将其中微观的复合材料的渐进损伤分析和有限元分析相结合，复合材料每层方向不同，当一层的树脂产生裂纹，其他层的纤维会进一步阻止裂纹的发展，线性分析难以观测到该效应。

2 类结构



输入 input:

- Load : 应力或应变
- Vi: 树脂和纤维交界体积率,没有则为空或者0
- Vf: 纤维体积率
- Interface: 交界材料
- Matrix : 基底材料
- Fiber : 纤维材料

参数 params:

- Theory : 方法
- RUCid : 晶格编号，参见附录
- Name : 名称

- DamageFactor : 破坏对应材料参数的折减系数
- Damage : 开启微观力学的渐进损伤分析
- Criterion : 失效准则

输出 output :

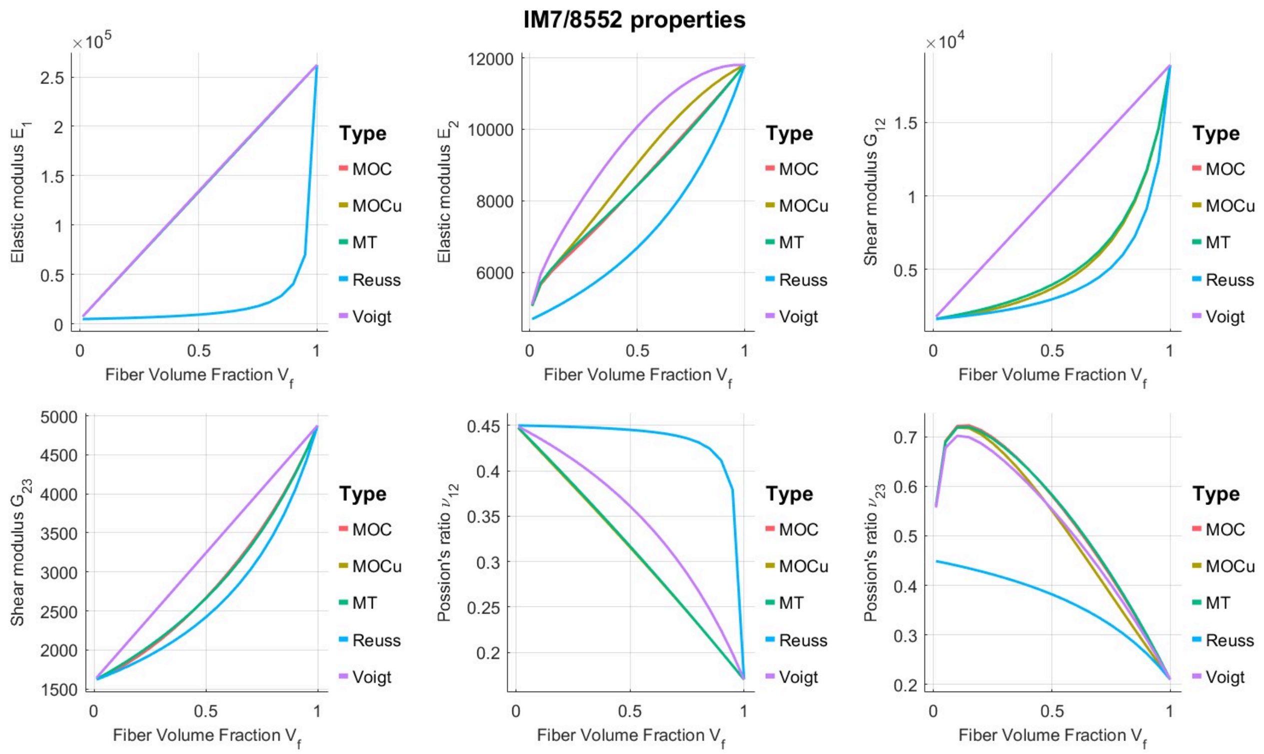
- DamageResult : 损伤分析结果
- MicroField: 微观晶格数据
- SG: 力的方向矢量
- Plyprops : 复合材料属性预测结果

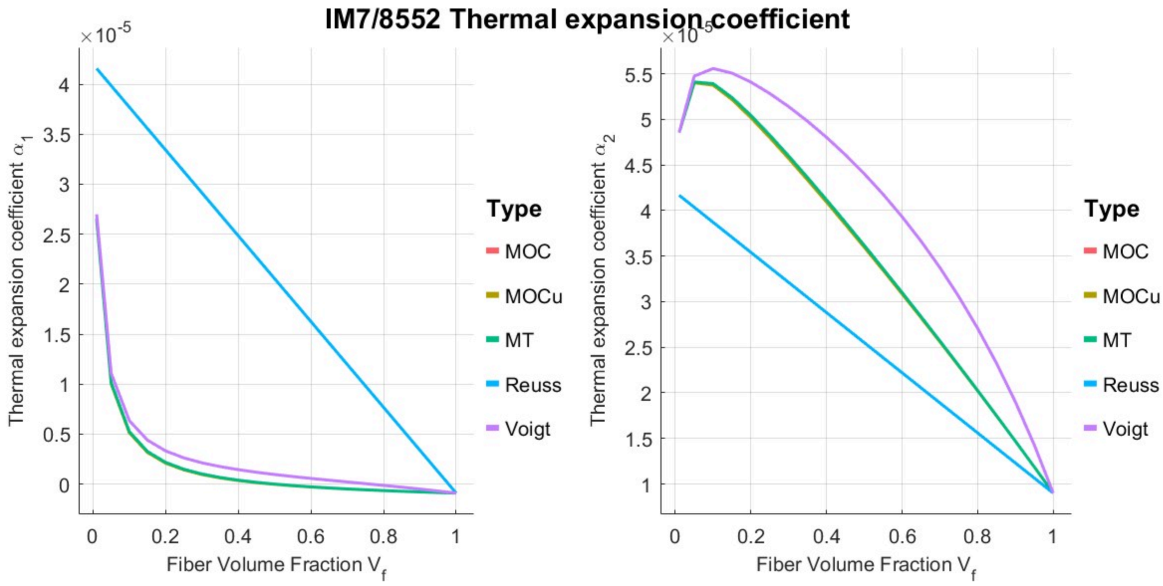
3 案例

3.1 Stand-alone micromechanics effective properties (Flag=1)

采用不同方法估算复合材料的属性。

```
S=RMaterial('Composite');
mat=GetMat(S,[3,4]');
inputStruct.Vf=0.55;
inputStruct.Fiber=mat{1,1};
inputStruct.Matrix=mat{2,1};
paramsStruct.Theory='All';
Ply= method.Composite.Micromechanics(paramsStruct, inputStruct);
Ply=Ply.solve();
Plot(Ply);
PlotAlpha(Ply);
```

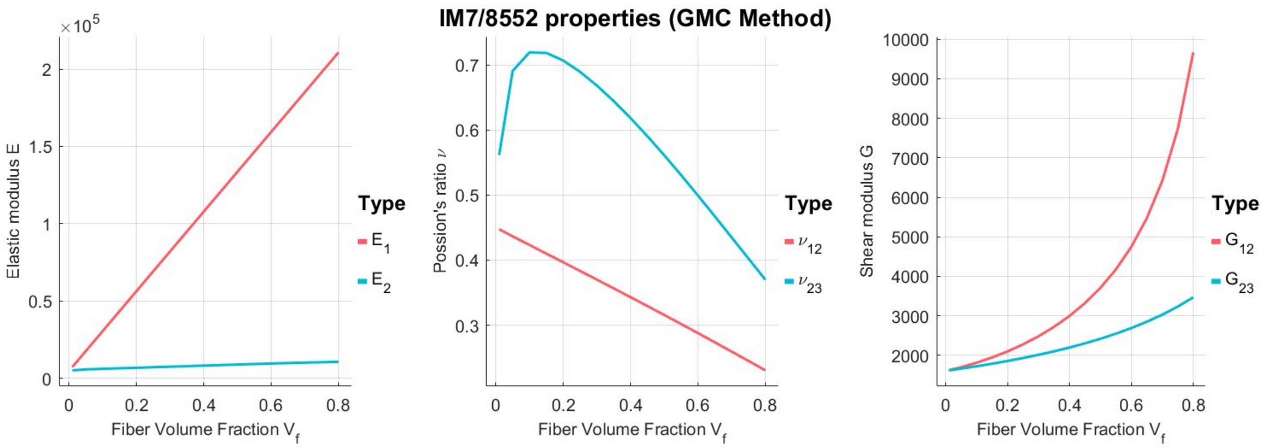


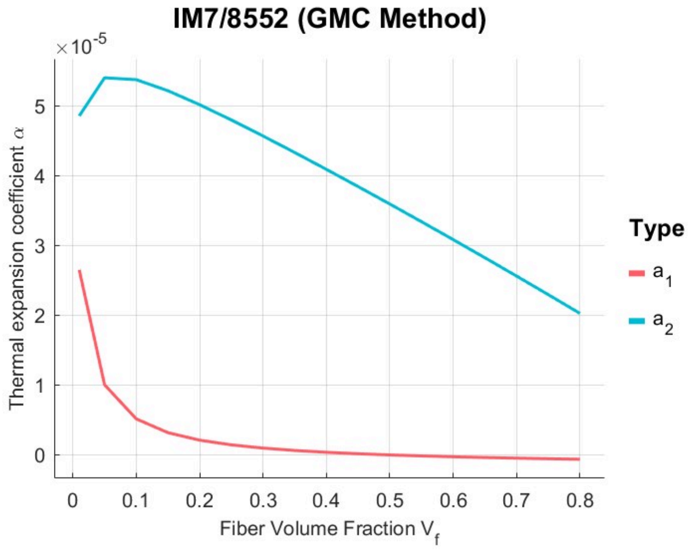


3.2 Stand-alone micromechanics effective properties using GMC (Flag=2)

采用GMC法估算复合材料属性。

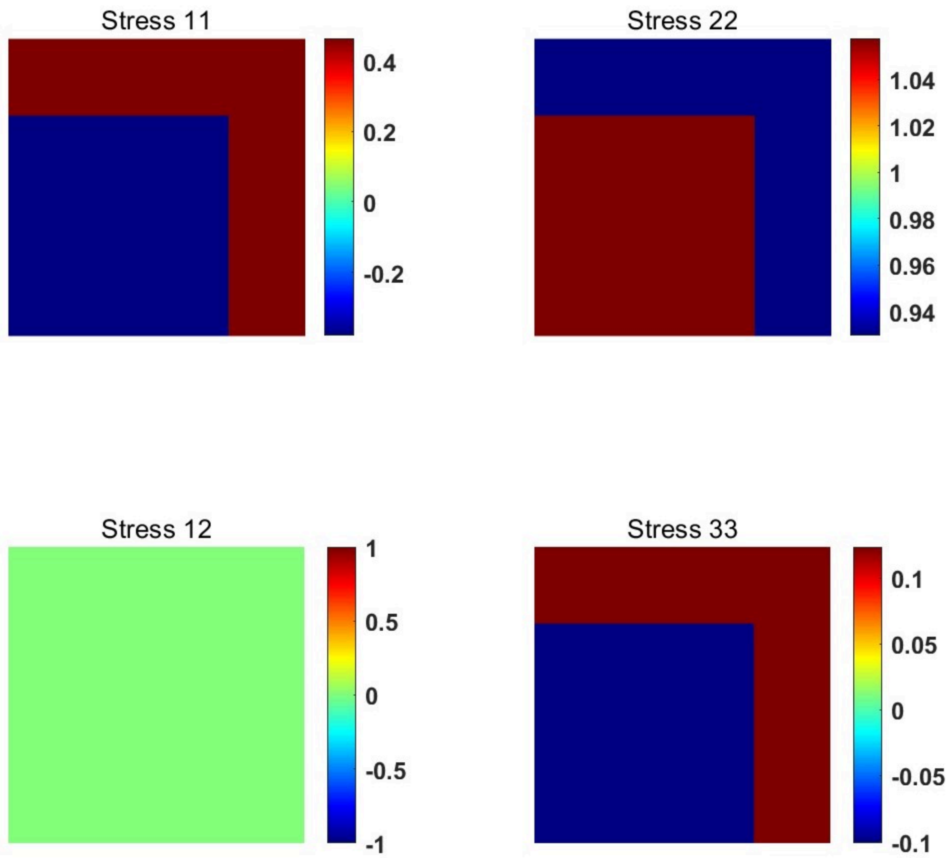
```
S=RMaterial('Composite');
mat=GetMat(S,[3,4]');
inputStruct.Vf=0.55;
inputStruct.Fiber=mat{1,1};
inputStruct.Matrix=mat{2,1};
paramsStruct.Theory='GMC';
paramsStruct.RUCid=26;% 2,7,26
Ply= method.Composite.Micromechanics(paramsStruct, inputStruct);
Ply=Ply.solve();
Plot(Ply);
PlotAlpha(Ply);
```

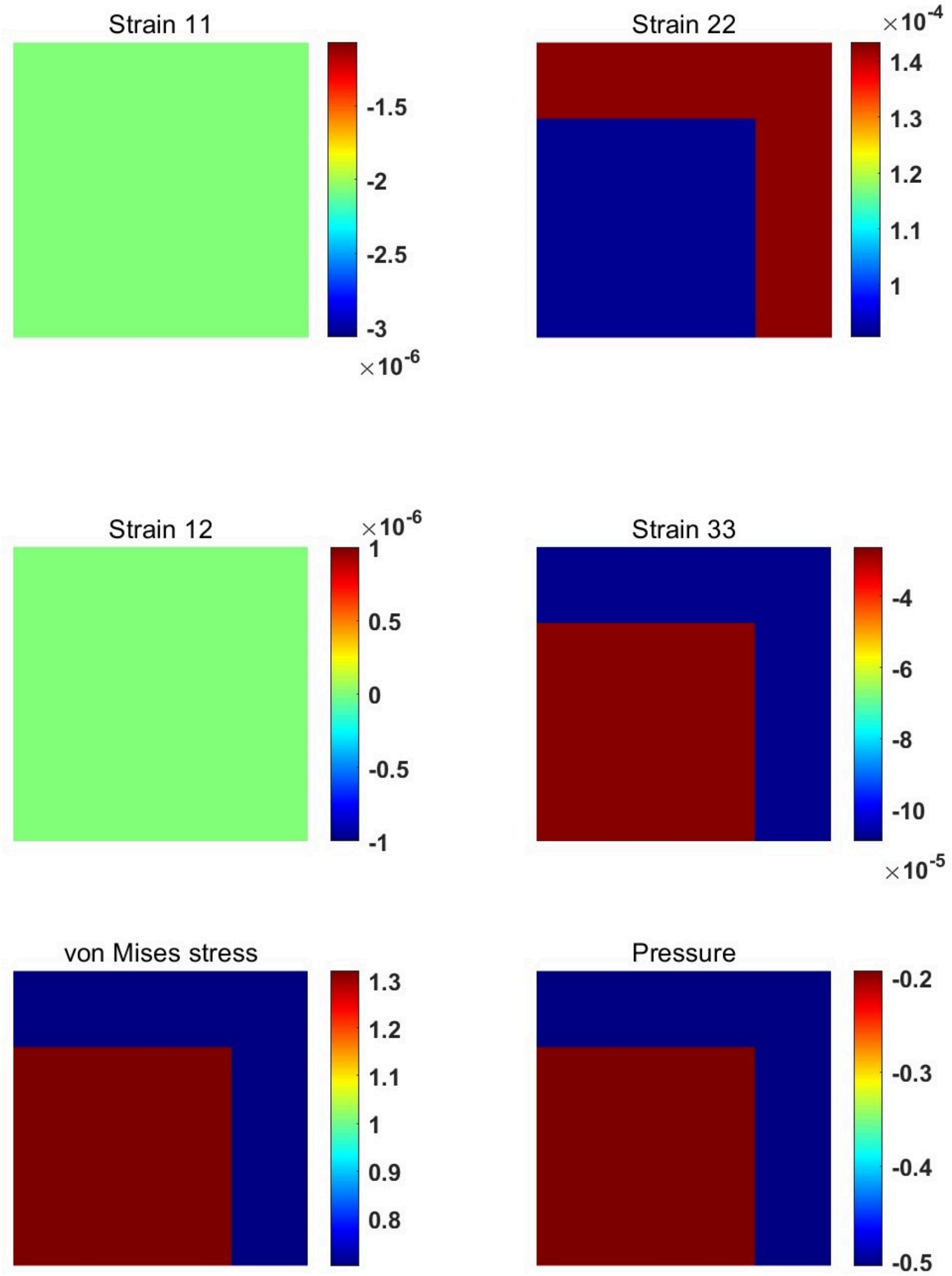




3.3 Plot Local field (Flag=3)

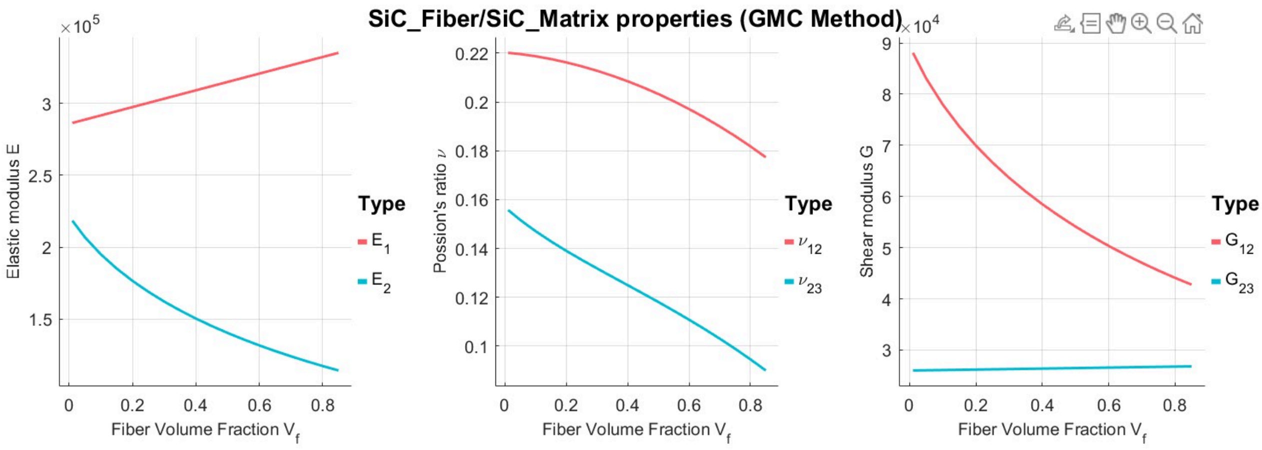
```
S=RMaterial('Composite');
mat=GetMat(S,[3,4]');
inputStruct.Vf=0.55;
inputStruct.Fiber=mat{1,1};
inputStruct.Matrix=mat{2,1};
inputStruct.Load.Type=[2,2,2,2,2,2];% 2-Stress 1-Strain
inputStruct.Load.Value=[0,1,0,0,0,0];
paramsStruct.Theory='MT';% 'Voigt' 'Reuss' 'MT' 'MOC' 'MOCu'
Ply= method.Composite.Micromechanics(paramsStruct, inputStruct);
Ply=Ply.solve();
PlotMicroField(Ply);
```

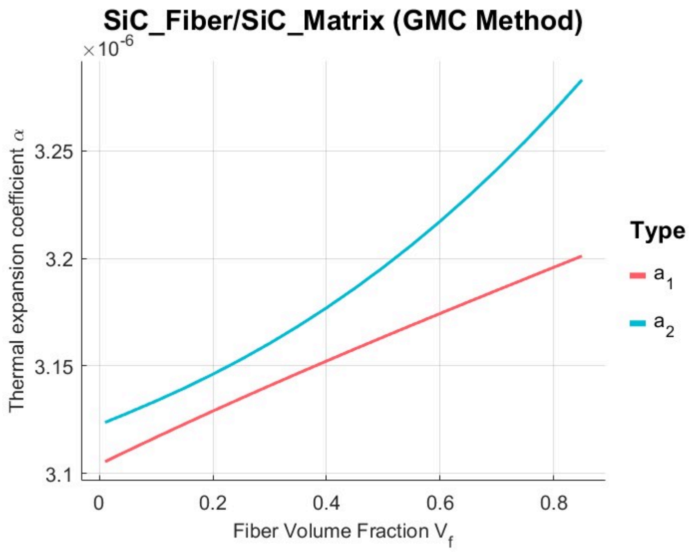




3.4 SiC-SiC with interface BN_Coating using GMC RUCid=105 (Flag=4)

```
S=RMaterial('Composite');
mat=GetMat(S,[29,30,31]');
inputStruct.Vf=0.28;
inputStruct.Vi=0.13;
inputStruct.Fiber=mat{1,1};
inputStruct.Matrix=mat{2,1};
inputStruct.Interface=mat{3,1};
paramsStruct.Theory='GMC';
paramsStruct.RUCid=105;
Ply= method.Composite.Micromechanics(paramsStruct, inputStruct);
Ply=Ply.solve();
Plot(Ply);
PlotAlpha(Ply);
```

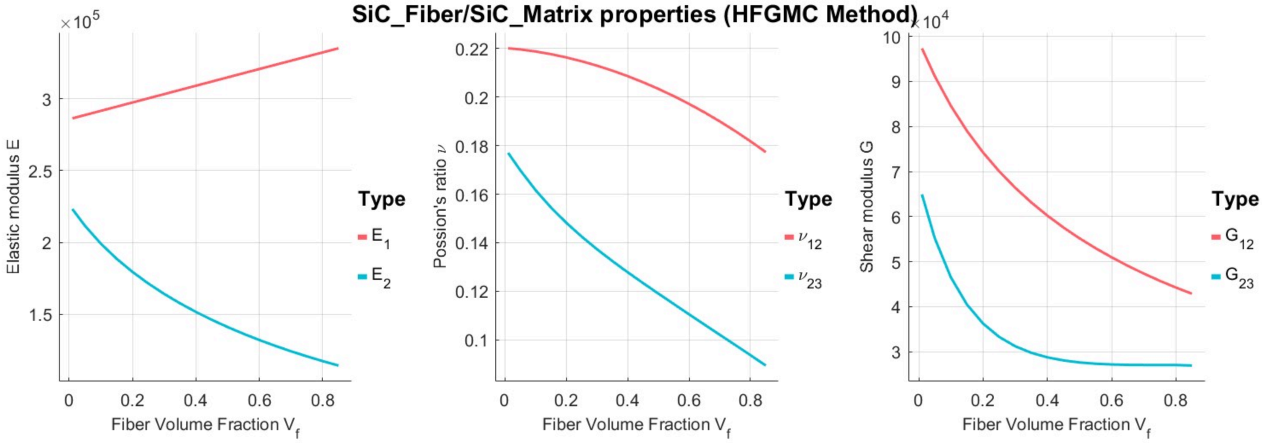


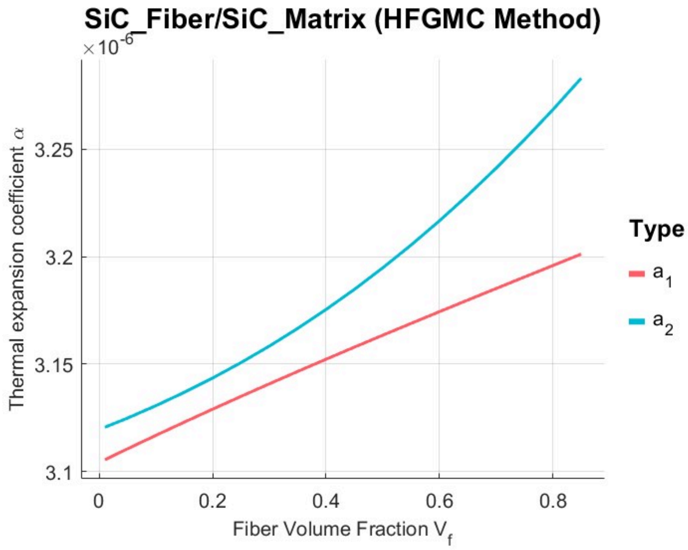


3.5 Stand-alone micromechanics effective properties using HFGMC (Flag=5)

采用HFGMC法估算复合材料属性。

```
S=RMaterial('Composite');
mat=GetMat(S,[29,30,31]');
inputStruct.Vf=0.28;
inputStruct.Vi=0.13;
inputStruct.Fiber=mat{1,1};
inputStruct.Matrix=mat{2,1};
inputStruct.Interface=mat{3,1};
paramsStruct.Theory='HFGMC';
paramsStruct.RUCid=105;
Ply= method.Composite.Micromechanics(paramsStruct, inputStruct);
Ply=Ply.solve();
Plot(Ply);
PlotAlpha(Ply);
```

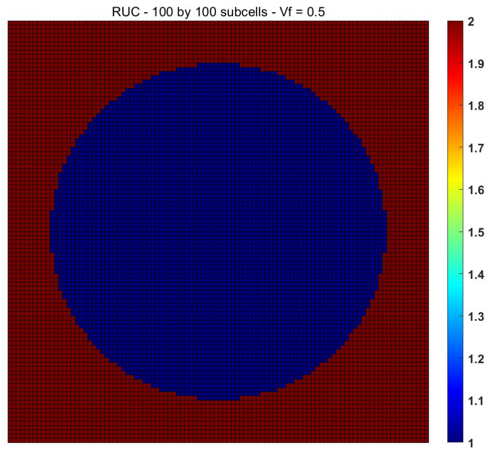


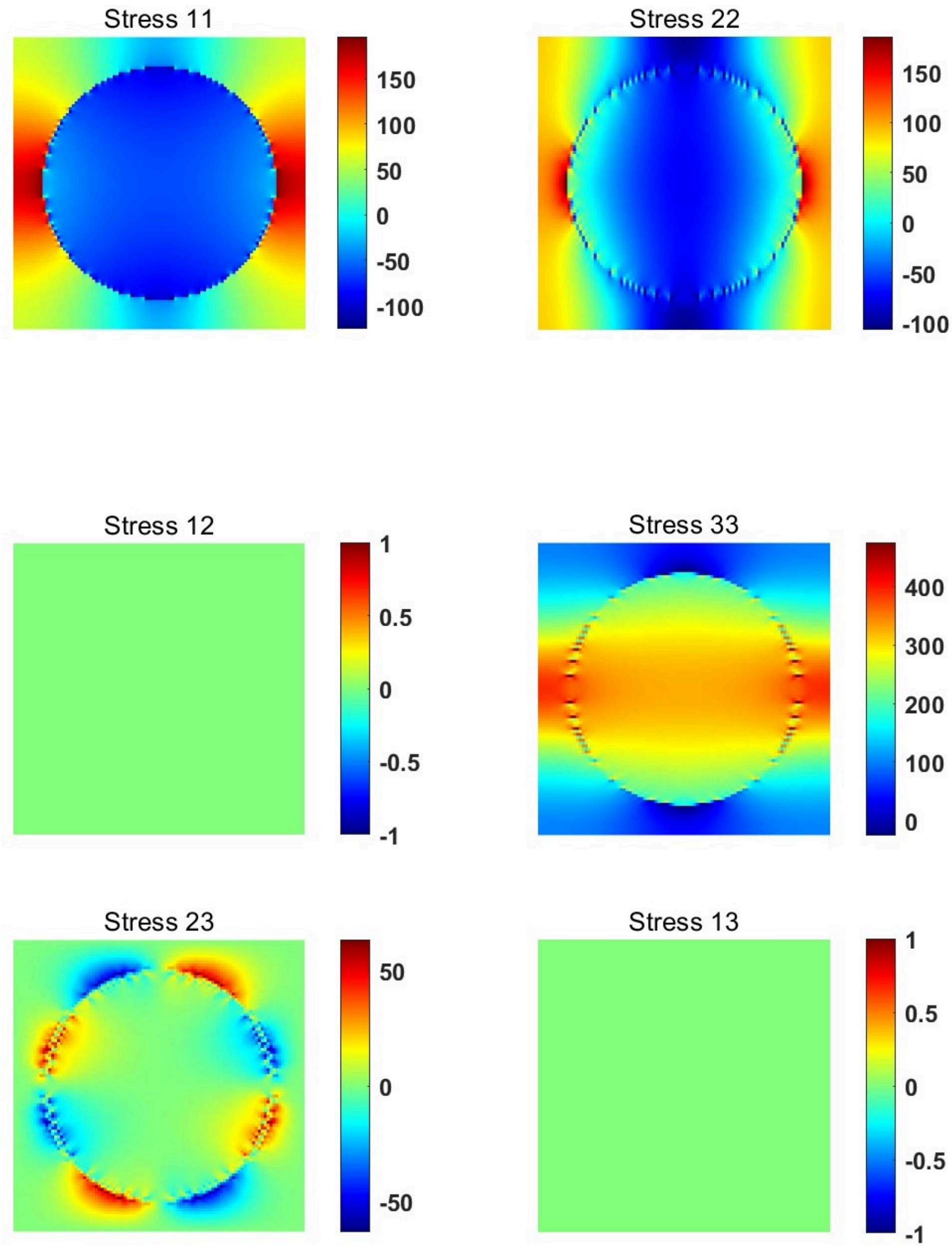


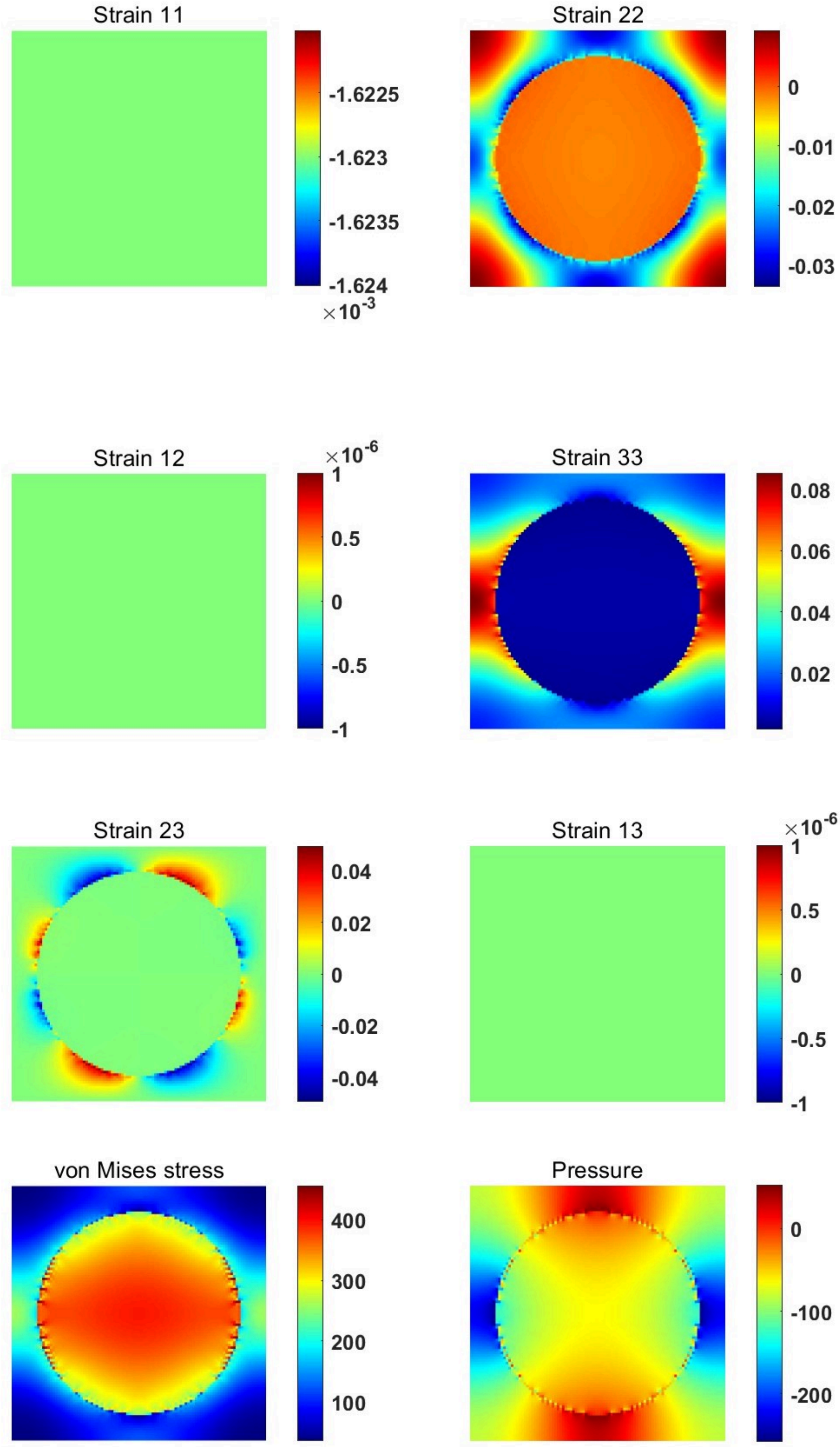
3.6 HFGMC vs FEA (Flag=6)

HFGMC和有限元方法对比

```
S=RMaterial('Composite');
mat=GetMat(S,[1,2]');
inputStruct.Vf=0.5;
inputStruct.Fiber=mat{1,1};
inputStruct.Matrix=mat{2,1};
inputStruct.Load.Type=[2,2,1,2,2,2];% 2-Stress 1-Strain
inputStruct.Load.Value=[0,0,0.02,0,0,0];
paramsStruct.RUCid=99;
paramsStruct.Theory='HFGMC';
Ply= method.Composite.Micromechanics(paramsStruct, inputStruct);
Ply=Ply.solve();
PlotMicroField(Ply);
```


RUC - 100 by 100 subcells - Vf = 0.5
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1


Stress 11
150
100
50
0
-50
-100
Stress 22
150
100
50
0
-50
-100
Stress 12
1
0.5
0
-0.5
-1
Stress 33
400
300
200
100
0
Stress 23
50
0
-50
Stress 13
1
0.5
0
-0.5
-1

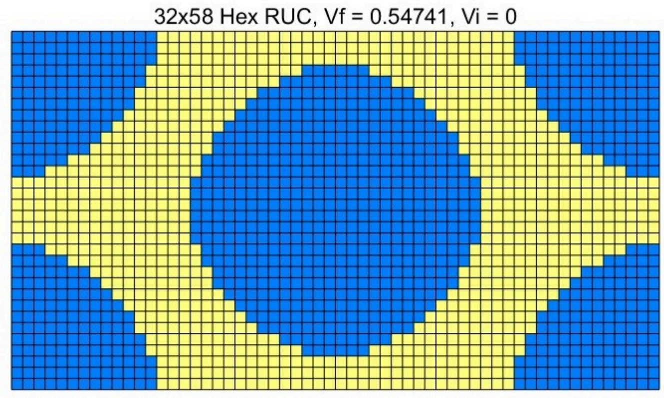


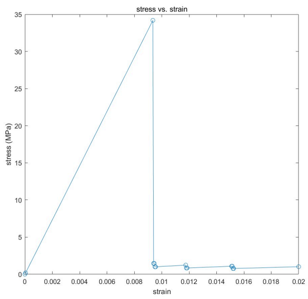
3.7 Progressive damage response using HFGMC and max stress criterion (Flag=7)

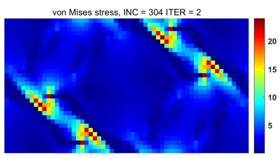
本例是微观状态下采用HFGMC方法做复合材料受剪切力作用下渐进损伤分析，可以看到树脂裂纹逐渐发展的过程，直到试件破坏，纤维没有起到承载作用，该方向的强度仅为35Mpa左右。

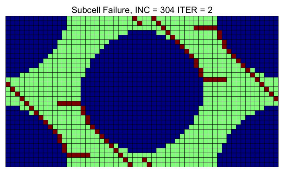
```
S=RMaterial('Composite');
```

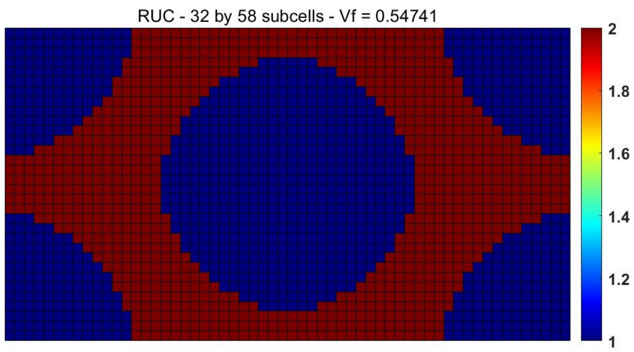
```
mat=GetMat(S,[1,2]');
inputStruct.Vf=0.55;
inputStruct.Fiber=mat{1,1};
inputStruct.Matrix=mat{2,1};
inputStruct.Load.Type=[2,2,2,1,2,2];% 2-Stress 1-Strain
inputStruct.Load.Value=[0,0,0,0.02,0,0];
inputStruct.Load.NINC=400;
paramsStruct.RUCid=200;
paramsStruct.Theory='HFGMC';
paramsStruct.Damage=1;% Progressive damage analysis
paramsStruct.Criterion=1; % Failure criterion
Ply= method.Composite.Micromechanics(paramsStruct, inputStruct);
Ply=Ply.solve();
PlotMicroField(Ply);
```

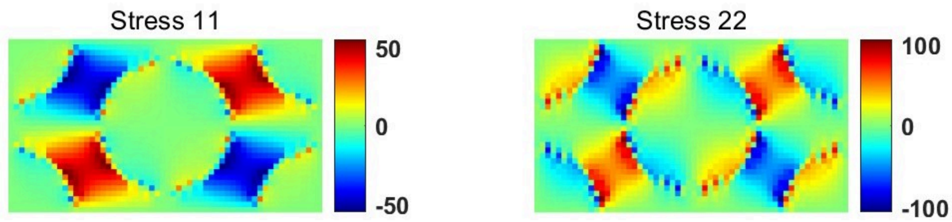


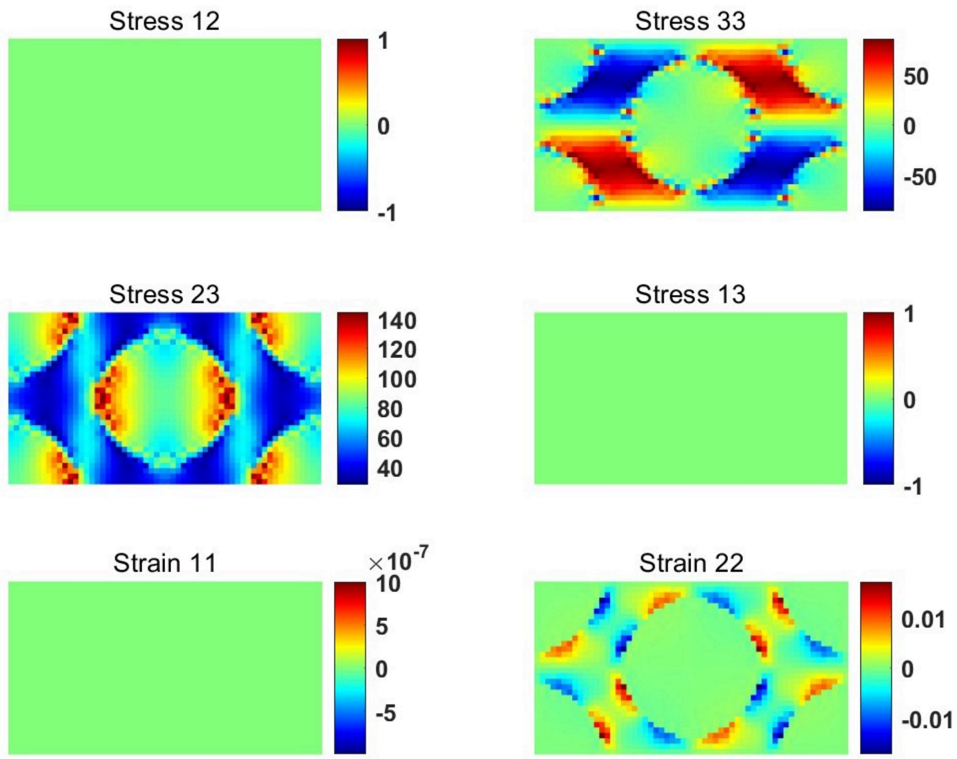


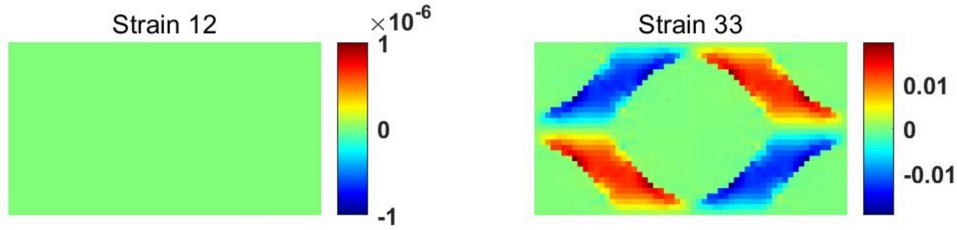


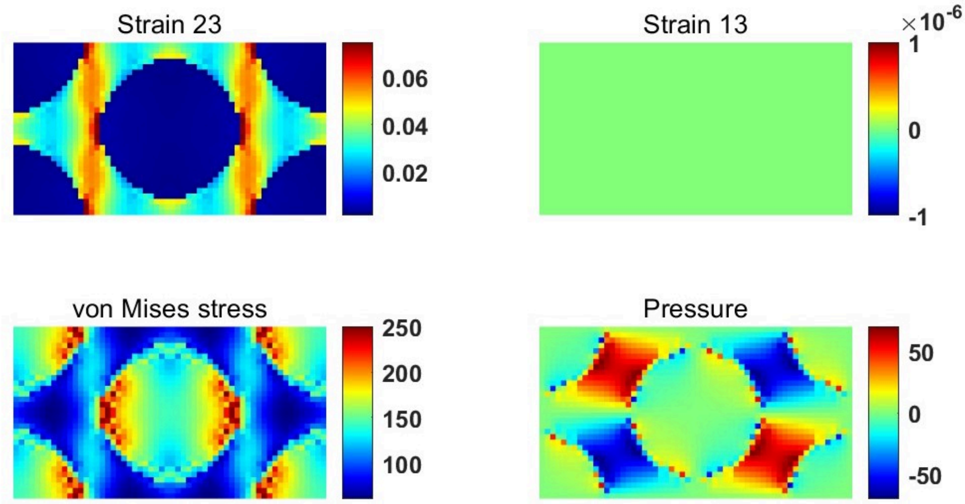





Stress 11
50
0
-50
Stress 22
100
0
-100


Stress 12
1
0
-1
Stress 33
50
0
-50
Stress 23
140
120
100
80
60
40
Stress 13
1
0
-1
Strain 11
×10^-7
10
5
0
-5
Strain 22
0.01
0
-0.01


Strain 12
×10^-6
1
0
-1
Strain 33
0.01
0
-0.01

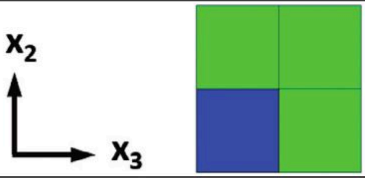
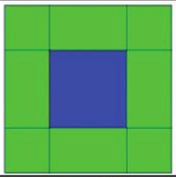
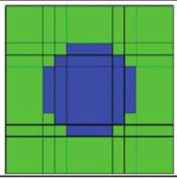
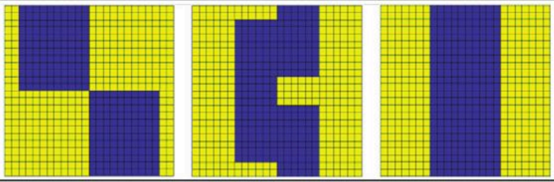
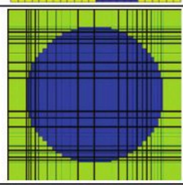
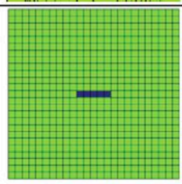
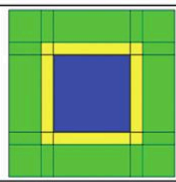
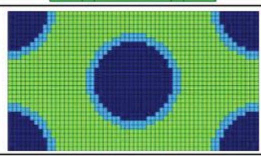
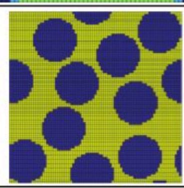


4 参考文献

[1] Practical micromechanics of composite materials

5 附录

晶格种类编号

`RUCid`	**Options in `GetRUC.m`**	**Schematic**
`2` (2x2)	-	
`3` (3x3)	-	
`7` (7x7)	-	
`8` (24x24)	Continuous, discontinuous, and overlap	
`26` (26x26)	`Extra`	
`30 – 33` (25x25 – 201x201)	-	
`99` (user defined)	Full RUC definition	?
`105` (5x5)	-	
`200` (hexagonal fiber packing)	`Target_Ni` and `Target_NG`	
`300` (random fiber packing)	`Nfibers`, `Radf`, `Tint and touching`	
`1000` (JSON file)	Read from JSON file	?