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Microwave Heating at the Grain Level

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Introduction

Microwave heating
and
Processing

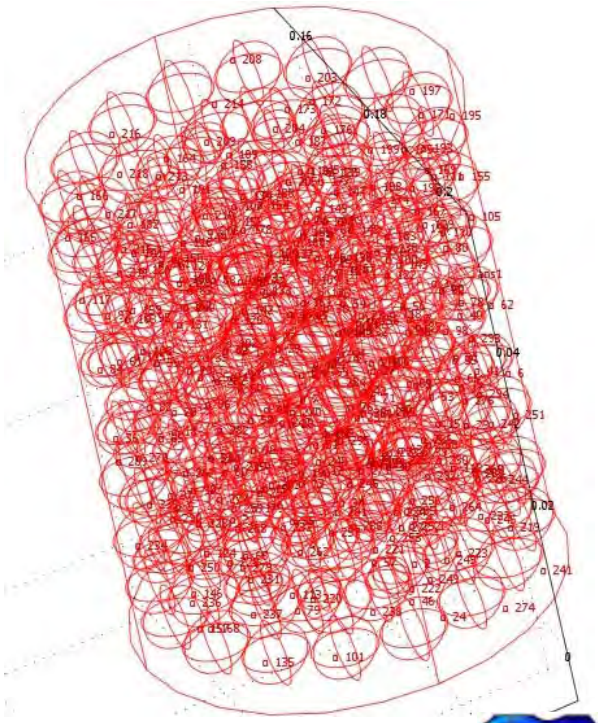
of heterogeneous materials

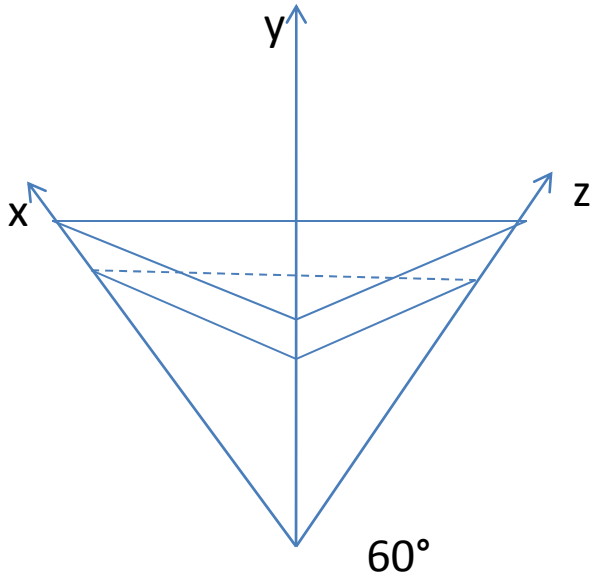
physical heterogeneity
surface effect
microwave effect ?

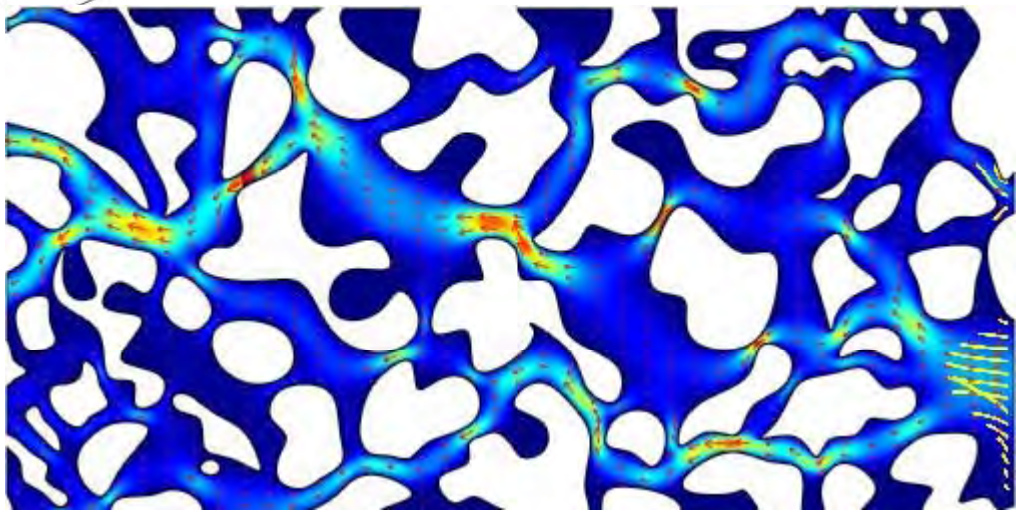
1 to draw the geometry

2 to solve the model

Actual drawing methods

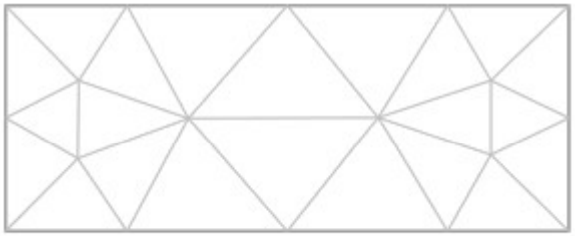




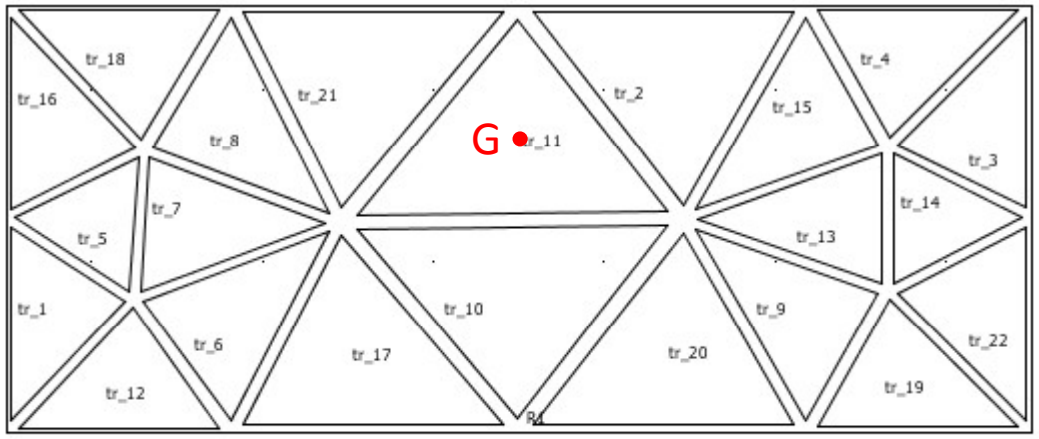


From Comsol meshes to geometrical elements

1- Draw mesh (for instance "extremely coarse")
run anything
Export/Postprocessing Data



2- Make some arrangements

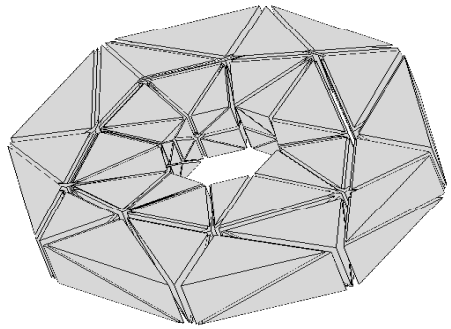



```
% Coordinates
pt=[-0.6              5.551115E-17
-0.6                  -0.1
-0.53593934     -0.036506012
-0.6                  -0.2
-0.53593934     -0.136506
.
.];
% Elements (triangular)
Tr=[2       3       5
1       3       2
2       5       4
3       6       5
8   9       11
.
.];
```

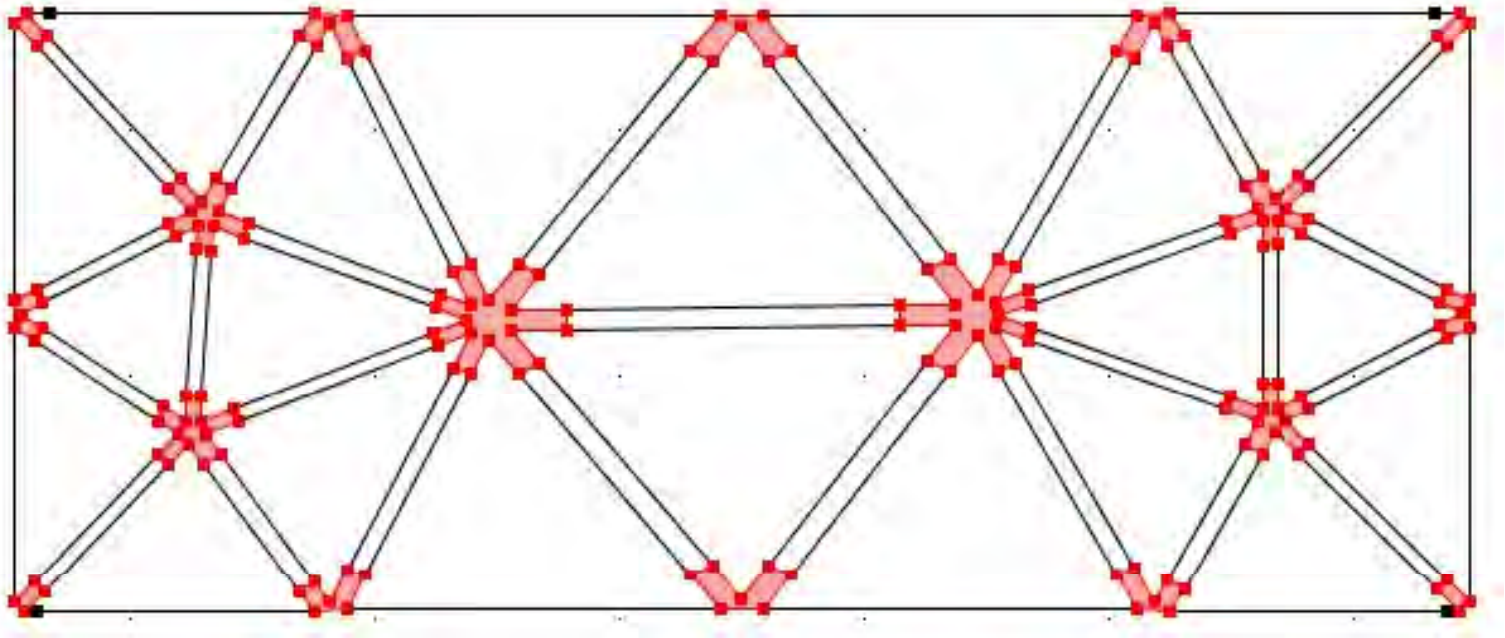
3- Write a script for automatic typing i.e.
fprintf(1,strcat('tr_',num2str(tt),'=poly2(','[',xxstr,']'
,',','[',yystr,']',');\n'))

4- Import the drawing into a new **.mph

```
%% ptG - centre of gravity of the base of tetrahedron
ptG=([Pt(pt1,1)+Pt(pt2,1)+Pt(pt3,1),Pt(pt1,2)+Pt(pt2,2)+Pt(pt3,2),Pt(pt1,
3)+Pt(pt2,3)+Pt(pt3,3)])/3;

%% ptH -centre of gravity of tetrahedron
ptH=([(ptG(:,1)+S(:,1))/4, (ptG(:,2)+S(:,2))/4, (ptG(:,3)+S(:,3))/4 ]);

%% rh - homothety coefficient
rh=0.7;

xx1=[Pt(pt1,1) Pt(pt2,1) Pt(pt3,1) Pt(pt4,1)];
yy1=[Pt(pt1,2) Pt(pt2,2) Pt(pt3,2) Pt(pt4,2)];
zz1=[Pt(pt1,3) Pt(pt2,3) Pt(pt3,3) Pt(pt4,3)];

%% homothety
xxx=ptH(1,1)+rh*(xx1-ptH(1,1));
yyy=ptH(1,2)+rh*(yy1-ptH(1,2));
zzz=ptH(1,3)+rh*(zz1-ptH(1,3));

geomplot(tetrahedron3([xxx; yyy; zzz]));
hold('on')
```

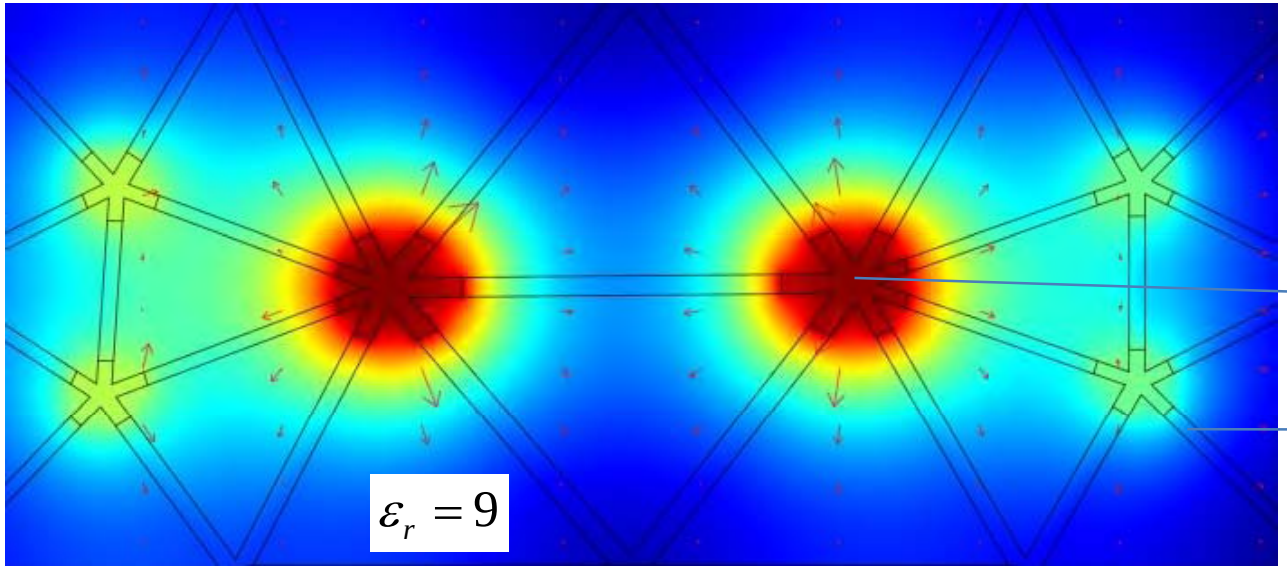


Example



Applications : macroscopic parameters

V



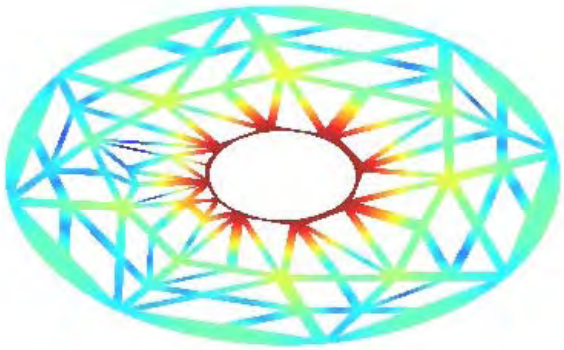
ground

$\varepsilon_{moyen,t} = f(\varepsilon_i, T_i)$

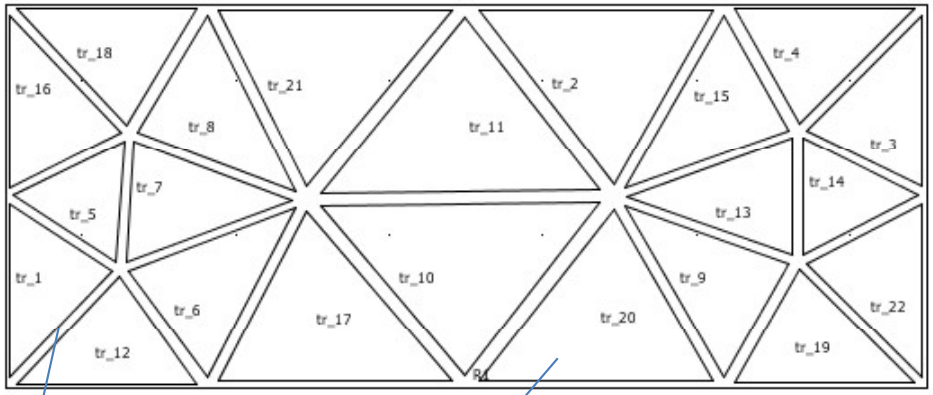
T_i

Puissance micro-onde incidente

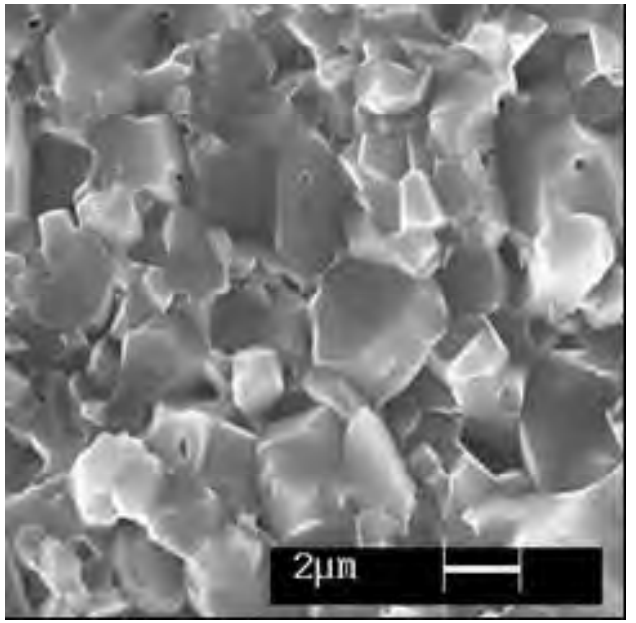
Puissance thermique diffusée

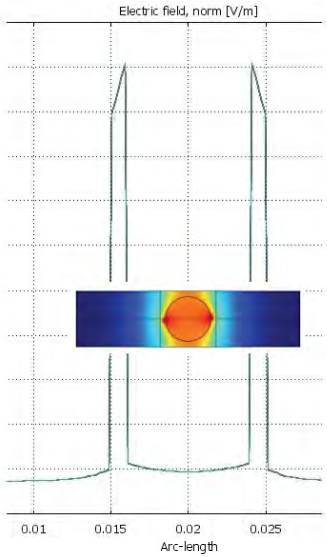


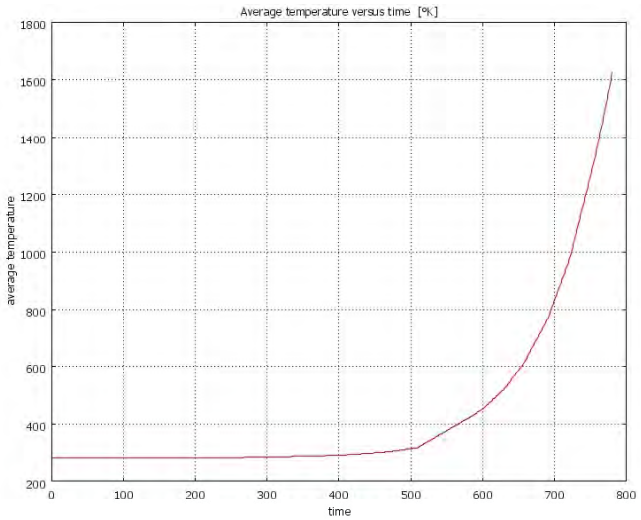
Applications : microwave sintering of alumina



nano powder micro powder



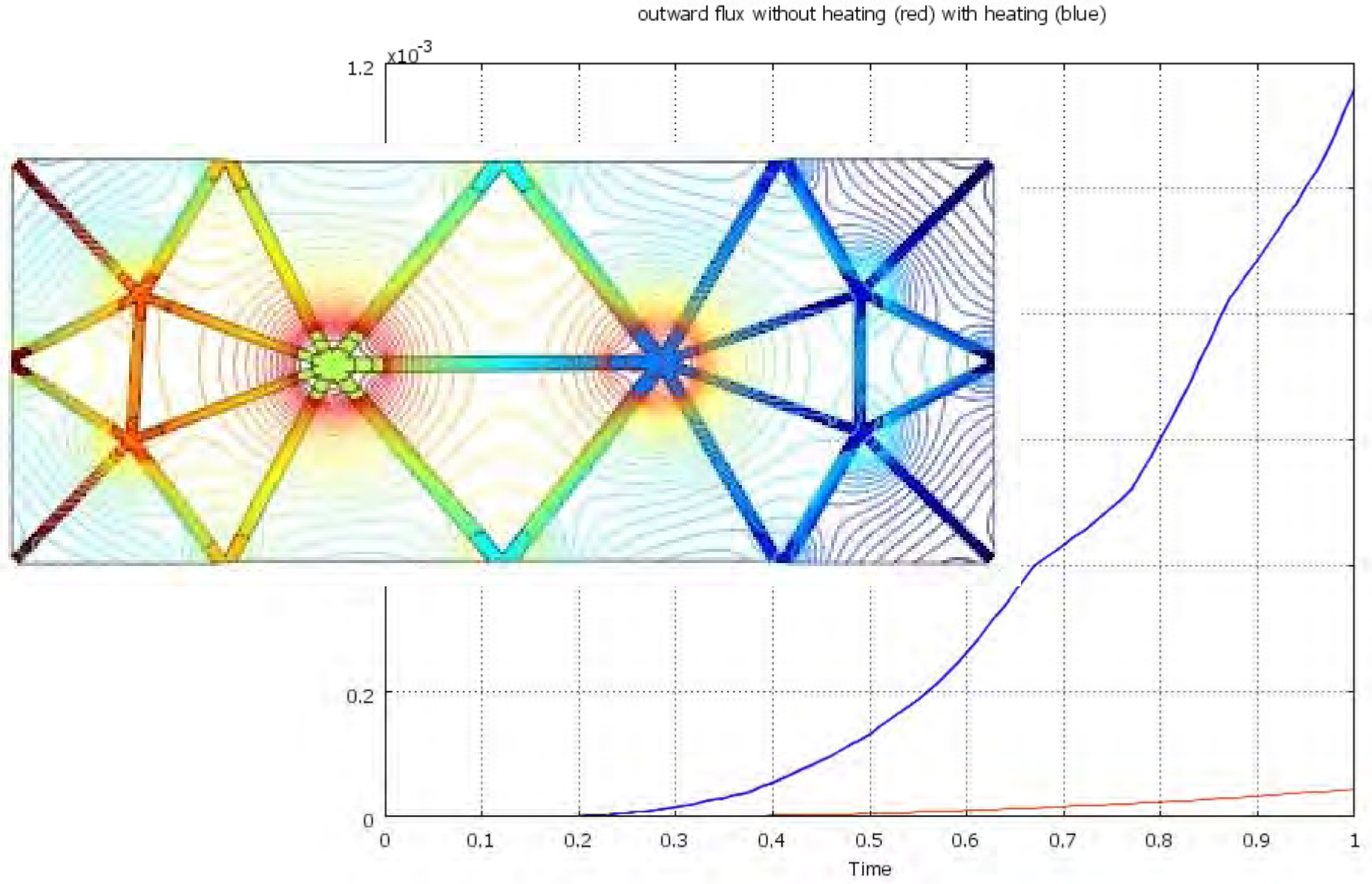




Grain size (d, µm)	5÷7
Density (ρ, g/cm^3)	3,82÷3,91
Young's modulus (E, GPa)	360÷370
Poisson's ratio (ν)	0,23÷0,26
Bending strength (σ_B, MPa)	350÷400
Vickers hardness (HV, GPa)^2	17÷20
Indentation fracture toughness, (K_{Ic}, MPa·m$^{1/2}$)	5÷5,6

$\sigma \approx \sigma_0(|E|>E_0)$ $\sigma=\sigma_0 (T-T0)^2$

Applications : drying of plugs inside a porous material




Thank you for listening
You are welcome to the next AMPERE meeting
Toulouse September 2011, 6th to 9th