

SECTION 7. Mechanics and machine construction.



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**COMPUTER MODEL OF THE INFLUENCE OF MAGNETIC FIELDS
OF THE DOMAINS IN THE FORM OF MICRO-CRACKS AT
FRACTURE OF METALS**

The article discusses the model of development of micro-cracks in the metal and its computer realization.

Keywords: domain, metal corrosion.

Consider for a General theory of the magnetic moments of atoms and molecules[1-6]. As is known the atoms of all the substances consist of a positively charged nucleus and moving around him negatively charged

electrons. Every moving in the orbit of the electron forms a circular current of force

$$I = e\nu,$$

ν - is the frequency of Rotation of the electron around the nucleus.

Because the negative charge of the electron, the direction of the current and the direction opposite to the motion of the electron. Magnetic moment generated by the electron current in magnitude is equal to:

$$p_m = I\pi r^2 = e\nu\pi r^2 = \frac{e\omega r^2}{2},$$

$\omega = 2\pi\nu$ – the angular velocity; r – is the radius of the electron orbit.

Magnetic moment \vec{p}_m is created by the motion of the electron on the orbit owing to what its called - orbital magnetic moment of the electron. Vector \vec{p}_m forms with the vector of the orbital velocity of the electron \vec{v} left system. Orbiting the planet electron has the momentum, called orbital mechanical moment of the electron:

$$M = mvr = m\omega r^2.$$

Vector \vec{M} forms with the velocity vector \vec{v} right system. Therefore, the vectors \vec{p}_m and \vec{M} opposite.

The ratio of the magnetic moment of an elementary particle to its mechanical moment is called gyromagnetic attitude G . The orbital motion of the electron is the ratio is:

$$\Gamma = \frac{p_m}{M} = -\frac{e}{2m}$$

In the experiments, Einstein - de Haas (A. Einstein, 1879-1955; A. Haas, 1884-1941) and Barnett (Barnett S., 1873-1956), it turned out that along with the orbital moments, an electron has also its own mechanical momentum (spin) \vec{M}_s and its own magnetic moment \vec{p}_{ms} , which gyromagnetic ratio was twice as big:

$$\Gamma_s = \frac{p_{ms}}{M_s} = -\frac{e}{m}$$

Magnetic moment of an atom consists of orbital and self-magnetic moments of its constituent electrons and magnetic moment of the nucleus of an atom. Magnetic moment of the nucleus due to the magnetic moments included in a nucleus of protons and neutrons, much less electronic magnetic moments, therefore, addressing many issues neglected. Thus, the total magnetic moment of the atom is equal to the vector sum of the magnetic moments of all of its electrons. Magnetic moment of a molecule is composed of magnetic moments of its constituent electrons.

Moreover, the magnetization of the individual domain [7], especially at the poles, can not only change but, and smeared.

Destruction of materials is the last step of limit States of construction elements and materials [7, p.63]. Destruction of materials, elements occur on some regularities, and eventually break the metal, obviously, on the borders of “reomens”, the existence of which is considered in [8].

Our observations and the results of experiments show that the final form of the destroyed part of same form. To identify the mechanism of destruction and forms of microcracks, we considered several aspects.

As is known [10], the magnetic moments of atoms due to the exchange interaction at temperatures, smaller than a certain critical temperature (Curie temperature T_c), are oriented parallel to each other.

The exchange interaction, if we consider the quantum mechanical principle of Pauli, which characterizes the structure of electron shells of atoms will in the atom in one quantum state to be no more than two electrons with opposite spins.

In parallel orientation of the intrinsic magnetic moments of electrons exchange energy is minimal, which leads to the appearance of spontaneous magnetization at $T < T_c$.

Exchange interaction isotropic nature (known from quantum physics). If we consider only this kind of interaction magnetization can be directed in any direction. However, any crystalline solid is anisotropic. Due to the anisotropy's of a bench properties of a ferromagnetic vector of magnetization is built not arbitrarily, and in strictly certain directions. Usually this direction, corresponding to the crystallographic axes. For example, in cubic ferromagnets vector of magnetization can be directed along the edge of the cube, the diagonal of the faces of the cube or the main diagonal of the cube.

Most metals, forms one of the following high-symmetry gratings with dense packing of atoms: the cubic volume centric, cubic granet-centric and hexagonal [11].

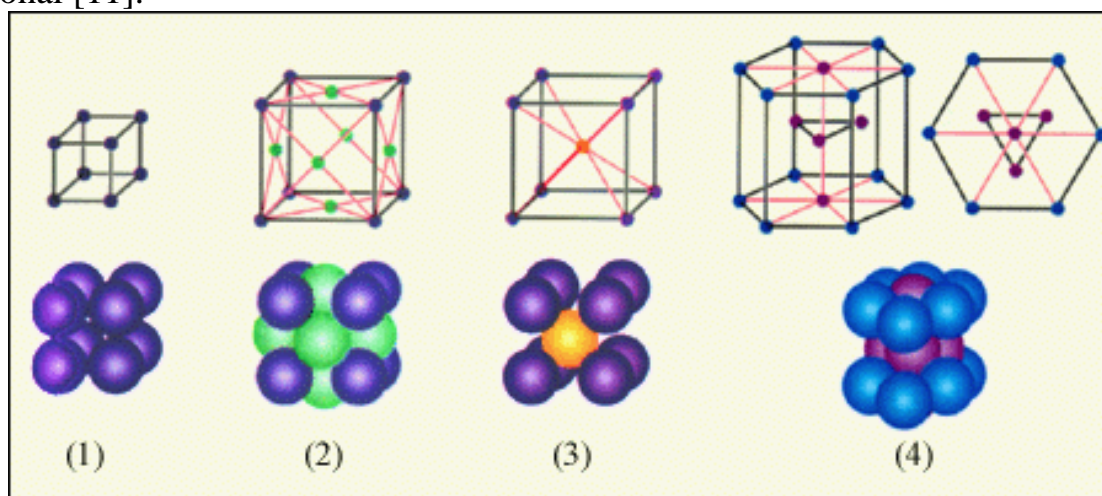


Figure 1 - Highly symmetric lattices [12]:

1 - simple cubic lattice;

- 2 - face-centred cubic lattice;
- 3 - body-centred cubic lattice;
- 4 - a hexagonal lattice.

Consider a metal with a simple cubic lattice. For the beginning we will consider the problem on the plane. Location attractors will set in an arbitrary manner as the orientation of the crystal lattice:

code Delphi

```
procedure TForm1.Button1Click(Sender: TObject);
var bb:boolean;
k,x0,y0:integer;
s:string;
begin
bmp:=tbitmap.Create;
bmp.Width:=1000;          bmp.Height:=600;

bmp2:=tbitmap.Create;
bmp2.Width:=bmp.Width;   bmp2.Height:=bmp.Height;
bmp3:=tbitmap.Create;
bmp3.Width:=bmp.Width;   bmp3.Height:=bmp.Height;

n:=0;
r:=5;
d:=2*r;
dd:=d-r/3;

nt:=strtoint(edit1.Text);
randomize;
for I := 1 to nt do
begin
x:=random(bmp.Width);  y:=random(bmp.Height);  alf:=random(360);

bb:=true;
for k := 0 to n-1 do//t.Count - 1 do
begin
x0:=xyz[k].x;
y0:=xyz[k].y;

if (sqrt(sqr(x0-x)+sqr(y0-y))<dd) then bb:=false;
end;
application.processmessages;
if bb then
```

```
begin
xyz[n].x:=x;
xyz[n].y:=y;
xyz[n].alf:=alf;
inc(n);
box(x,y,alf,bmp);
end;
end;
  button3.Click;
end;
```

We obtain a (Fig.2)

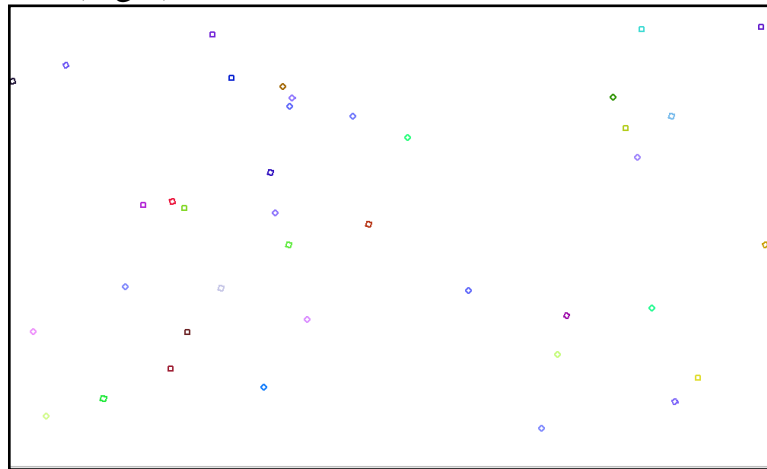


Figure 2 - Random location and direction of the crystal lattice.

Observe the growth of certain lattices around attractors (fig.3-4).

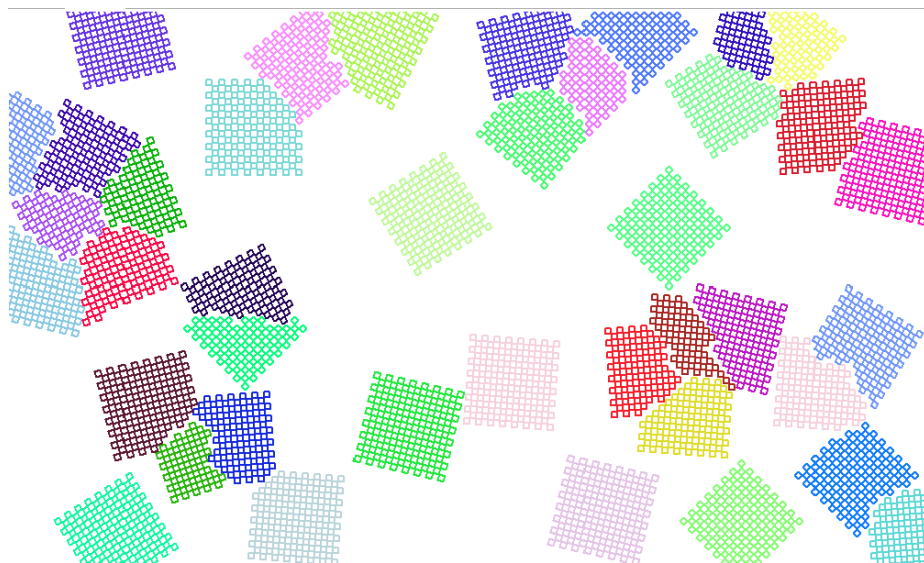


Figure 3 - The growing of crystals on attractors.

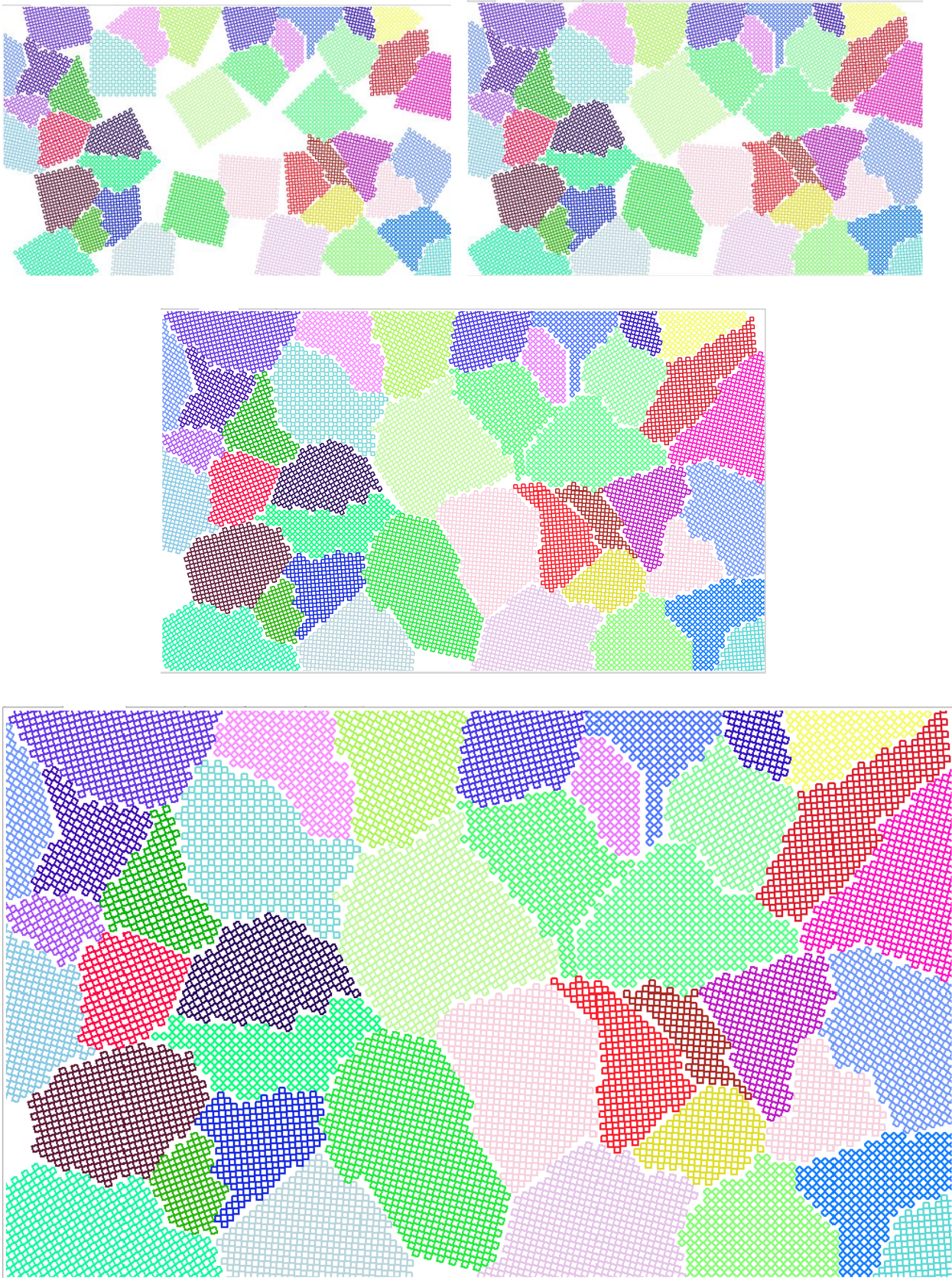


Figure 4 - The Process of crystallization of metal.

Algorithm crystallization we write in the form of:

code Delphi

```
procedure TForm1.Button3Click(Sender: TObject);
var i:integer;
begin
pagecontrol1.TabIndex:=1;
for I := 1 to 20 do begin
button2.Click ;
application.processmessages;
image1.Picture.Bitmap:=bmp;
end;
    button4.Click;
end;

procedure TForm1.Button2Click(Sender: TObject);
var s:string; i,j,k:integer;
begin

for I := 0 to n do
begin
x:=xyz[i].x;
y:=xyz[i].y;
alf:=xyz[i].alf;
if (x>0)and(x<bmp.Width)and (y>0)and(y<bmp.Height)then
begin
coord(x,y,alf);

for j := 1 to 8 do
begin
bb:=true;
bob(j);
    application.processmessages;
if bb then

begin
box(xy[j].X,xy[j].Y,alf,bmp);
xyz[n].x:=xy[j].X;
xyz[n].y:=xy[j].Y;
xyz[n].alf:=alf;
inc(n);

end; end; end; end;
```

```
end;
```

As a result of (Fig.4), we obtain separately formed crystals (domains). In which individual molecules are connected by covalent bonds, and separate domains intermolecular. It is natural to assume that any faults will occur only along the intermolecular bonds - as the weakest.

With this in mind we allocate the boundaries of the domains (Fig.5), the magnetization vector will coincide with the direction of the crystal lattice of the attractor (Fig.6). We obtain the following algorithm:

code Delphi

```
procedure TForm1.Button4Click(Sender: TObject);
var s:string; kk, i,j,k,x1,y1,alf1:integer;
bb:boolean;
begin
kk:=0;
pagecontrol1.TabIndex:=2;
for I := 1 to n do//t.Count - 1 do
begin
image2.Picture.Bitmap:=bmp2;

x:=xyz[i].x;
y:=xyz[i].y;
alf:=xyz[i].alf;

for k := 0 to i-1 do
begin
application.processmessages;
x1:=xyz[k].x;
y1:=xyz[k].y;
alf1:=xyz[k].alf;

if alf<>alf1 then
if
(sqrt(sqr(X1-x)+sqr(Y1-y))<1.5*d) then
begin
box2(trunc((x1+x)/2),trunc((y1+y)/2),0,bmp2);

if (cos(abs(alf-alf1)/180*pi)<0) then
begin
inc(kk);
gr[kk].x:=trunc((x1+x)/2);
gr[kk].y:=trunc((y1+y)/2);
```



```
gr[kk].alf:=trunc(abs(alf-alf1));
end;

end;
end;
end;

pagecontrol1.TabIndex:=3;
application.processmessages;
for I := 0 to nt- 1 do
begin
x:=xyz[i].x;
y:=xyz[i].y;
alf:=xyz[i].alf;

box3(x,y,alf,bmp2);
application.processmessages;
end;
image3.Picture.Bitmap:=bmp2;
application.processmessages;

pagecontrol1.TabIndex:=4;
application.processmessages;
for I := 1 to kk do
begin
x:=gr[i].x;
y:=gr[i].y;
alf:=gr[i].alf;

box4(x,y,alf,bmp2);
box4(x,y,alf,bmp3);
application.processmessages;
end;

image4.Picture.Bitmap:=bmp2;

pagecontrol1.TabIndex:=5;
image5.Picture.Bitmap:=bmp3;

application.processmessages;

end;
```

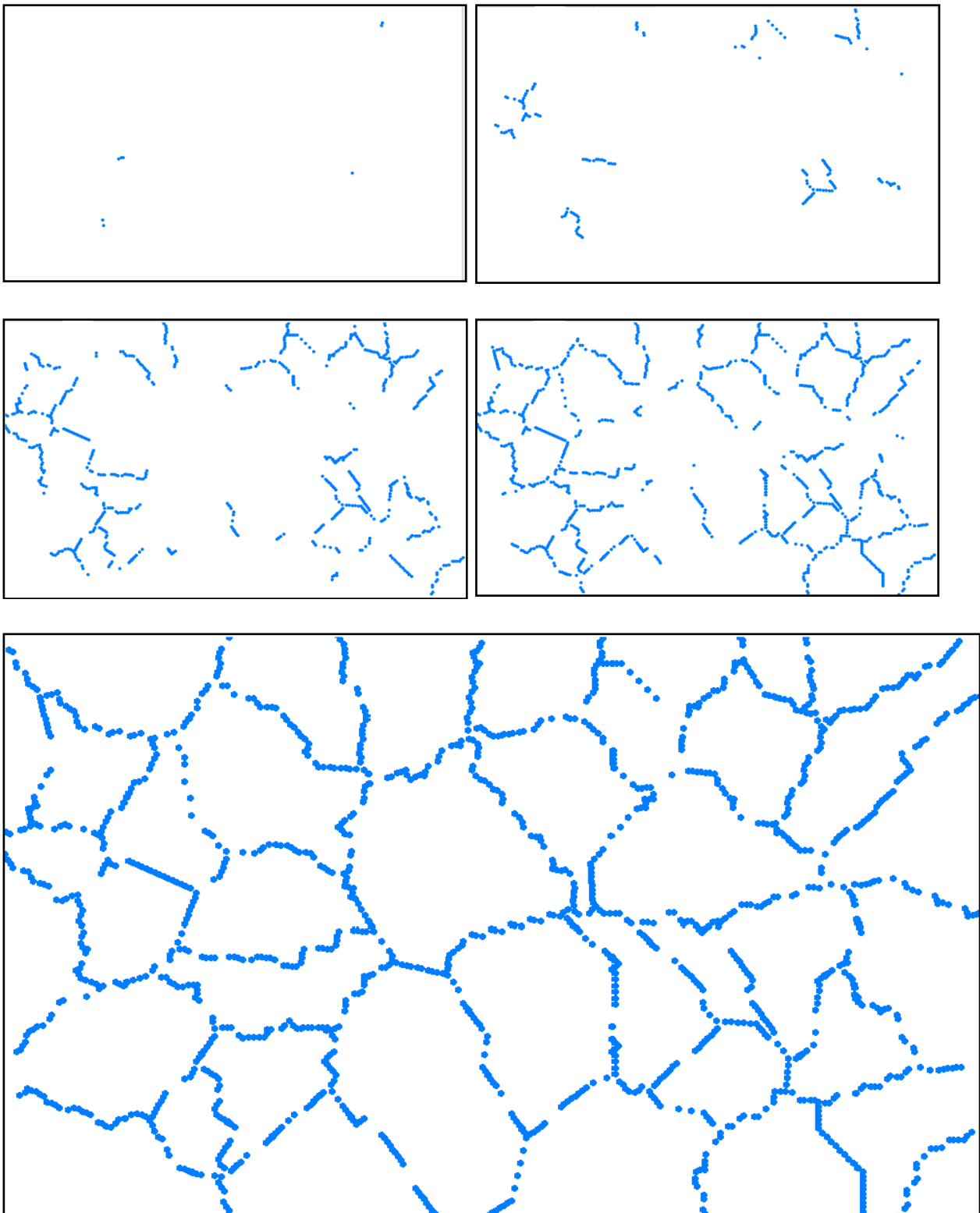


Figure 5 - Selection of the boundaries of the individual domains.

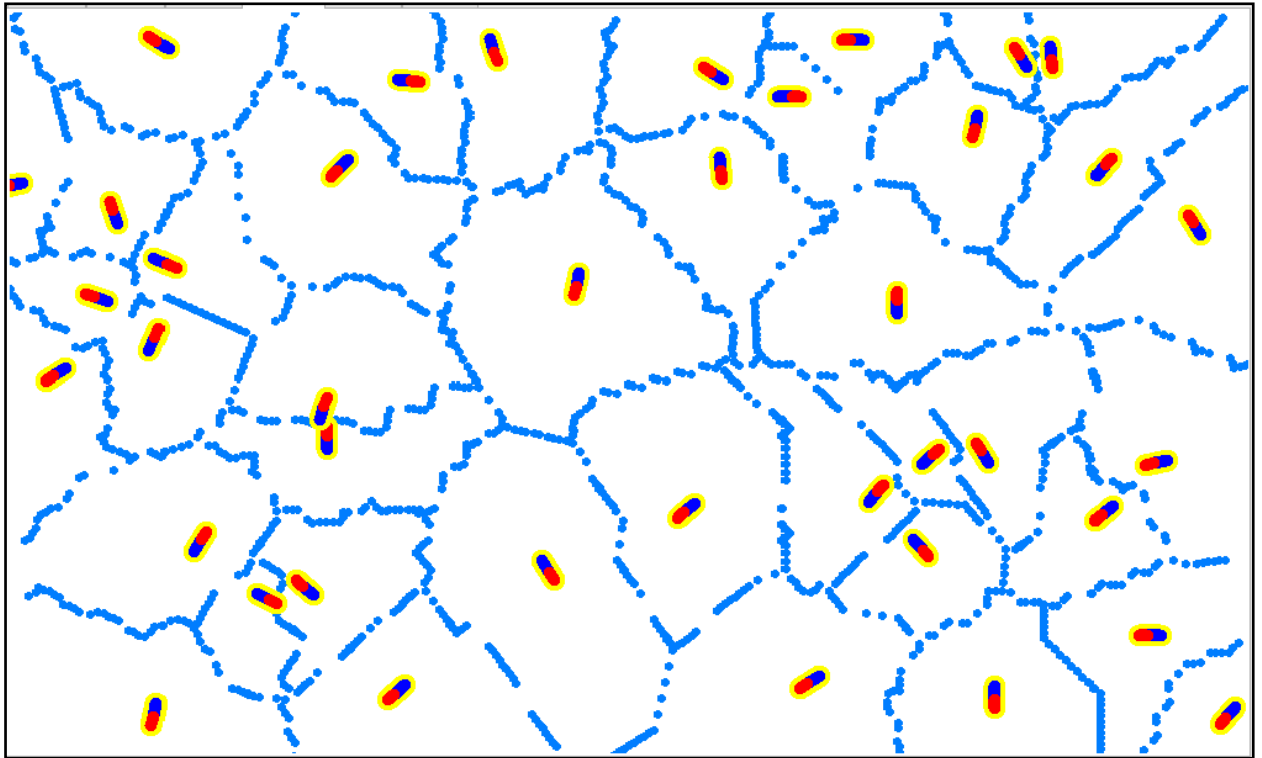


Figure 6 - Magnetization individual domains.

Each domain has a certain magnetic moment, and interacts with the nearest domains in case of equal poles - the intermolecular connections naturally be weaker than in the case of bipolar. Accordingly breaks and the appearance of microcracks more typical of the boundaries of the single-ended domains.

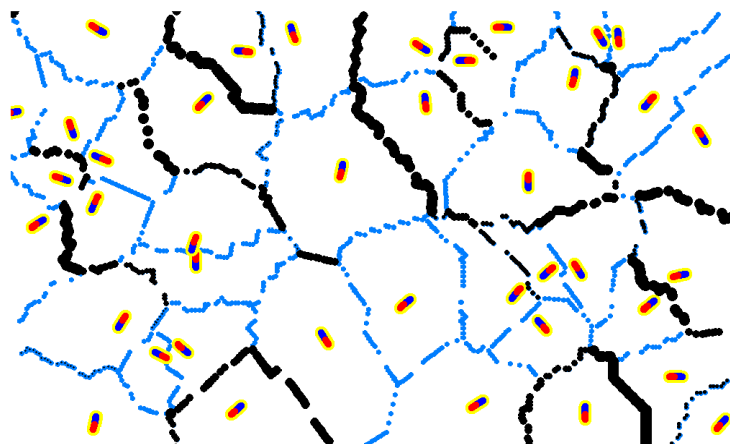


Figure 7 - The Emergence of micro cracks between the domains.

Finally, we obtain some form of cracks metal (Fig.8).

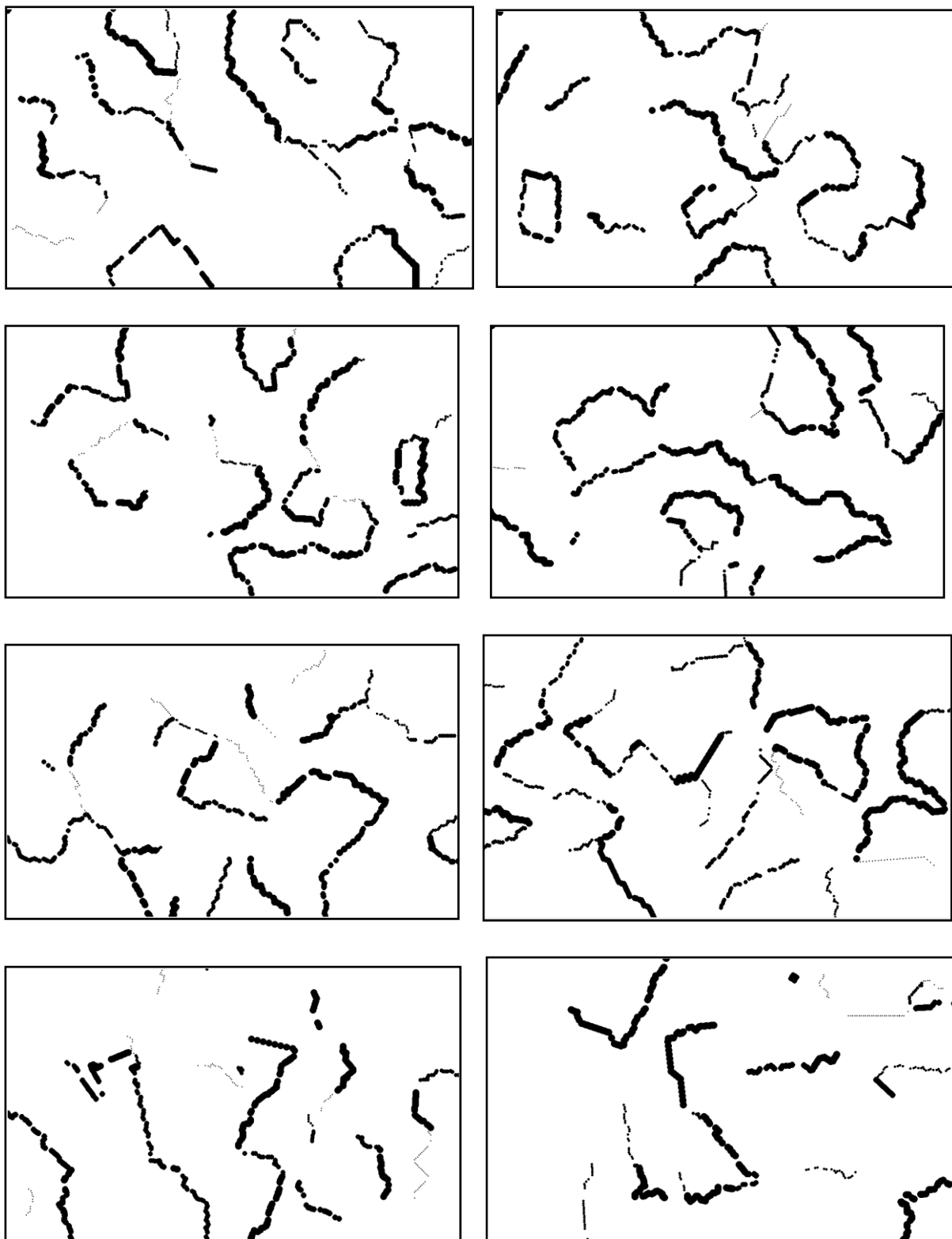


Figure 8 - A Form of development of cracks.

The data obtained are characteristic of microcracks steel, and match photos electron microscope (Fig.9).

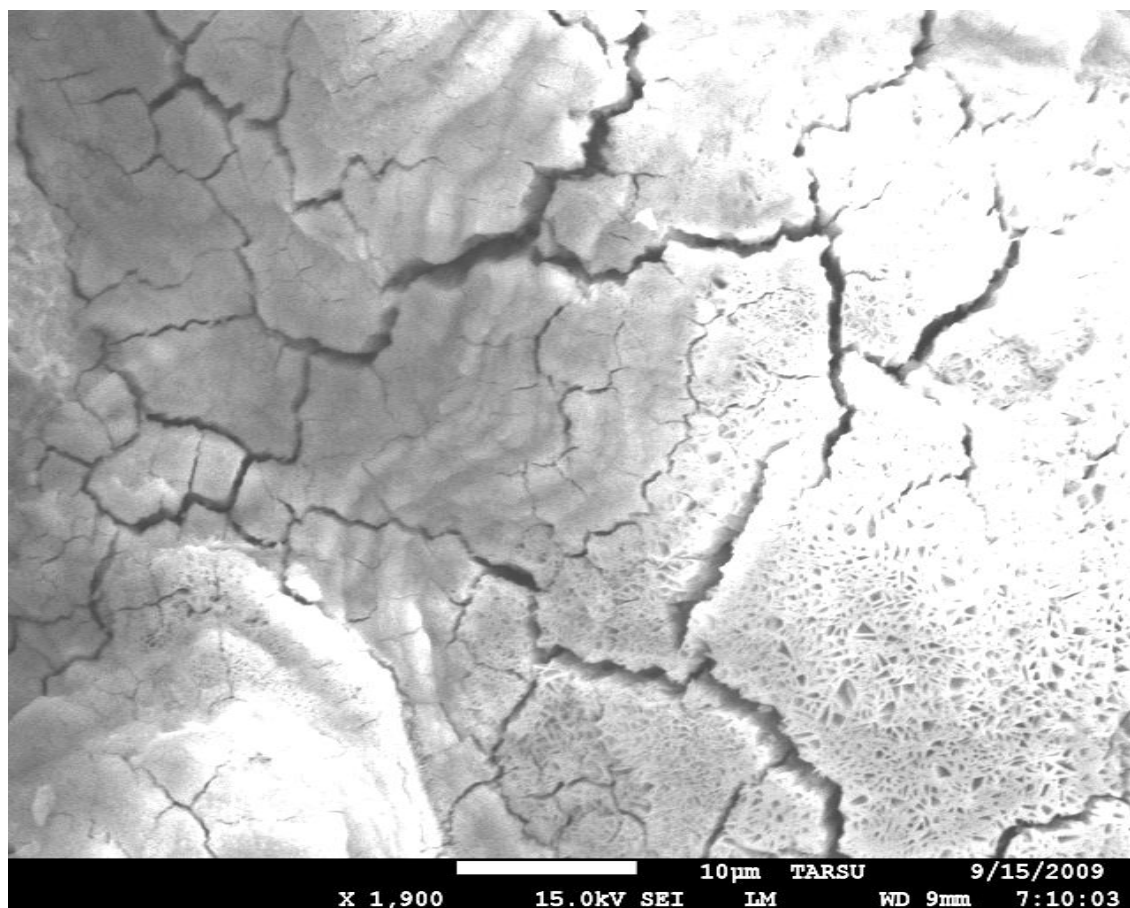


Figure 9 - The Surface of the metal increased in 1900.

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