

Include @PLASIMO_INPUTDATA_DIR/input/md2d/md2d-plugins.cnf Plugins
Type MicroDischarge

Author "Gerjan Hagelaar"

Version "\$Id: pdp_demo.md2d,v 1.12 2014/02/21 13:59:12 diana Exp \$"

Annotation "This plasma display panel (pdp) cell model is documented in the \nthesis of Gerjan Hagelaar."

```
InitViews {  
    ViewList {  
        Context wx  
        Viewer "Discharge Region/Species/He2+" "He2+ Density (m^-3)" "" ""  
        Viewer "Discharge Region/Species/He+" "He+ Density (m^-3)" "" ""  
        Viewer "Discharge Region/Species/e" "e Density (m^-3)" "" ""  
    }  
}
```

OutputFrequency 10

```
EM {  
    Type MicroDischarge  
}
```

```
Configuration { // 10/15  
    MaterialList {  
        mdMaterial {  
            Index 0  
            TypeDischargeGas  
            Name Discharge  
        }  
        mdMaterial {  
            Index 1  
            TypeElectrode  
            Name Grounded  
            SecEmissCorr 1.0  
        }  
        mdMaterial {  
            Index 2  
            TypeElectrode  
            Name Powered  
            SecEmissCorr 1.0  
        }  
        mdMaterial {  
            Index 3  
            TypeDielectricum
```

```

        Name    Glass
        Eps_r    6.0
        SecEmissCorr 1.0
    }
    mdMaterial {
        Index    4
        TypeElectrode
        Name    Data
        SecEmissCorr 1.0
    }
    mdMaterial {
        Index    5
        TypeDielectricum
        Name    InterChannelWall
        Eps_r    6.0
        SecEmissCorr 1.0
    }
    mdMaterial {
        Index    6
        TypeDielectricum
        Name    MicroSheet_LClayer
        Eps_r    5.0
        SecEmissCorr 1.0
    }
    mdMaterial {
        Index    7
        TypeDielectricum
        Name    NeighbouringChannel
        Eps_r    1.0
        SecEmissCorr 0.0
    }
}

```

```

mdGeometry {
    deltaX    1E-5*m
    deltaY    1E-5*m
    CoordSystem cartesian
    GeometryMatrix {

```

A

TypeProbe

↪ add others

```

        Coordinate 28 32
        Coordinate 32 32
    }
    _DataFormat {
        TypeMTV
        ShrinkFactor 2
    }
}

mdScheduleBlock {
    BlockDuration 10*us
    InitialTimeStep 1*ps
    MaxTimeStep 10*ns
    MaxRelDensChange 0.05
    NrWrites 10 → too change a lot
    _Potential {
        TypeLimitedInternalResistance
        V0 -400*V
        Vlimit -300*V
        R 100*kOhm
    }
    Potential {
        TypeConstant
        V0 -300*V
    }
    Potential {
        TypeConstant
        V0 -20*V
    }
    Potential {
        TypeConstant
        V0 0*V
    }
}

mdScheduleBlock {
    BlockDuration 30*us
    InitialTimeStep 1*ps
    MaxTimeStep 20*ns
    MaxRelDensChange 0.05
    NrWrites 3
    Potential {
        TypeConstant
        V0 0*V
    }
    Potential {

```

```

        TypeConstant
        V0 -20*V
    }
    Potential {
        TypeConstant
        V0 0*V
    }
}

mdScheduleBlock {
    BlockDuration 60*us
    InitialTimeStep 1*ps
    MaxTimeStep 20*ns
    MaxRelDensChange 0.05
    NrWrites 1 change little
    Potential {
        TypeConstant
        V0 0*V
    }
    Potential {
        TypeConstant
        V0 20*V
    }
    Potential {
        TypeConstant
        V0 0*V
    }
}

}

Mixture {
    Type MicroDischarge

    KineticModel {
        Type None
    }

    DischargeEM {
        Inertia no
    }

    NewBC 1

    LocalField 0

```

InitTe 2.0*eV

EnergyTable {

mdLookupTable {

XMultiplicator 1.0*V*cm⁻¹*Torr⁻¹*kB*0.026*eVT

YMultiplicator 1.0*eV

XYData {

0 0

1E-3 0.0390

0.002 0.0405

0.003 0.0420

0.007 0.0510

0.013 0.0600

0.03 0.0945

0.06 0.150

0.1 0.240

0.3 0.705

1 1.66

1.6 2.86

2 3.84

3 5.91

4 6.82

6 7.60

8 8.06

12 8.81

20 10.2

30 11.9

40 13.9

50 16.0

60 18.4

80 24.1

120 38.6

160 57.2

200 79.6

240 106

280 138

320 174

360 215

400 262

1000 3E2

100000 4E2

}

Annotation "electron mean energy E/p < 1 E. McDaniel, Collision phenomena in

ionized gases, pp. 536 E/p >= 1 BOLSIG 100%He E/p (V/cm/torr) energy (eV)"

```
}  
}
```

```
GasList {  
    Pressure 200*Torr  
    GasTemperature 0.026*eVT  
    Gas {  
        Name      He  
        PressFrac 1.0  
        State {  
            TypeAtom  
            Weight 1 # check  
            Energy 0*eV # guessed  
        }  
    }  
}
```

```
mdSpeciesList {  
    EnforceInitialNeutrality e  
    mdParticle {  
        Name      e  
        State {  
            TypeAtom  
            Weight 2  
            Energy 0*eV  
        }  
        SecEmissCoeff 0.0  
        SecondaryEmissionEnergy 1.0*eV  
        ReflectionCoefficient 0.0  
        InitDens 0.5e8*cm^-3  
        DiffCoef {  
            Type Einstein  
        }  
        Mobility {  
            Type muN(E/N)  
            mdLookupTable {  
                XMultiplicator 1.0*V*cm^-1*Torr^-1*kB*0.026*eVT  
                YMultiplicator 1.0*Torr*cm^2*V^-1*s^-1/(kB*0.026*eVT)  
                Annotation "E/p<1 E. McDaniel, Collision phenomena in ionized gases, pp.  
540 E/p>=1 BOLSIG 100%He E/p (V/cm/torr) mu.p (torr.cm2/V/s). 0,1000: Calculated from  
Hasted, pp.331+338"  
            }  
            XYData {  
                0 9.6E6  
            }  
        }  
    }  
}
```

```

        6E-4 8.33E6
        0.004    7.5E6
        0.01 6.5E6
        0.02 5.5E6
        0.04 4.25E6
        0.06 3.5E6
        0.1  2.8E6
        0.2  2E6
        0.4  1.4E6
        0.6  1.17E6
        0.8  1E6
        1    8.68E5
        1.2  8.01E5
        1.6  7.18E5
        2    6.74E5
        3    6.5E5
        4    6.55E5
        8    6.69E5
        12   6.79E5
        20   7E5
        30   7.3E5
        40   7.65E5
        60   8.38E5
        80   9.09E5
        120  1.02E6
        160  1.1E6
        240  1.19E6
        320  1.25E6
        400  1.31E6
        1000 1.4E6
    }
}
}
}

mdParticle {
    Name      He+
    State {
        TypeAtom
        Weight  2    # check
        Energy  24.58*eV
    }
    SecEmissCoeff 0.20
    SecondaryEmissionEnergy 8.0*eV
}

```



```

ReflectionCoefficient 0.0
InitDens 0.5e8*cm^-3
DiffCoef {
    Type Einstein
}
Mobility {
    Type muN(E/N)
    mdLookupTable {
        XMultiplier 0.32181*V*cm^-1*Torr^-1*`kB*0.026*eVT
        YMultiplier 834.6755*Torr*cm^2*V^-1*s^-1/(`kB*0.026*eVT)
        Annotation "He+ - He. H.W.  Ellis et al., Atomic Data & Nucl Data Tab,
17,177 (1976) * M. McFarland et al., J. of Chem. Phys. vol. 59, no. 12 (1973), pp. 6610
E/P(V/cm/Torr)=0.32181*E/n(Td), mu.p=834.6755*mu0 E/n (Td)    mu0 (cm2/V/s). 0: McFarland, >
1000: Extrapolation 1/sqrt(E/p)"
        XYData {
            0    10.4
            6    10.3
            8    10.2
            10   10.2
            12   10.1
            15   10.0
            20   9.90
            25   9.74
            30   9.60
            40   9.28
            50   8.97
            60   8.67
            80   8.12
            100  7.67
            120  7.25
            150  6.78
            200  6.12
            250  5.60
            300  5.19
            400  4.58
            500  4.17
            600  3.81
            700  3.57
            1000 2.99
            1400 2.52
            1800 2.23
            2200 2.01
            2600 1.85
            3000 1.72
        }
    }
}

```

```

        5000    1.34
        10000   0.94
        1E5    0.94
    }
}
}
}

```

```

mdParticle {
    Name      He2+
    State {
        TypeAtom
        Weight  2    #check
        Energy  23.03*eV
    }
    SecEmissCoeff 0.20
    SecondaryEmissionEnergy  8.0*eV
    ReflectionCoefficient  0.0
    InitDens 0.5e8*cm^-3
    DiffCoef {
        Type Einstein
    }
    Mobility {
        Type  muN(E/N)
        mdLookupTable {
            XMultiplier 0.32181*V*cm^-1*Torr^-1*kB*0.026*eV
            YMultiplier 834.6755*Torr*cm^2*V^-1*s^-1/(kB*0.026*eV)
            Annotation "He2+ - He. H.W.  Ellis et al., Atomic Data & Nucl Data Tab,
17,177 (1976) * M. McFarland et al., J. of Chem. Phys. vol. 59, no. 12 (1973), pp. 6610 E/n (Td)
mu0 (cm2/V/s)  mu0=mu*(p/760)(273.16/T) 0,31-93: McFarland > Extrapolation 1/sqrt(E/p)"
        }
        XYData {
            0    16.7
            2    16.7
            3    16.8
            6    16.8
            8    16.9
            10   16.9
            12   17.0
            14   17.2
            16   17.3
            18   17.5
            20   17.7
            22   18.0
            24   18.3
        }
    }
}

```

```

        31 19.0
        47 19.3
        70 18.0
        93 16.0
        140 13.0
        200 10.9
        300 8.9
        500 6.9
        1000 4.9
        2000 3.5
        3000 2.8
        5000 2.2
        10000 1.5
        1E5 1.5
    }
}
}

mdParticle {
    Name          He*
    State {
        TypeAtom
        Weight 1      # check
        Energy 20.215*eV # guessed
    }
    SecEmissCoeff 0.0
    SecondaryEmissionEnergy 1.0*eV
    ReflectionCoefficient 0.0
    InitDens 1.0e8*cm^-3
    DiffCoef {
        Type Constant_DN
        DN 450.0*cm^2*s^-1*Torr/(`kB*0.026*eVT)
    }
    Annotation "Handbook of Physical Quantities"
}

mdParticle {
    Name          e*
    State {
        TypeAtom
        Weight 2      # check
        Energy 20.215*eV # guessed
    }
}

```

```

SecEmissCoeff      0.1
SecondaryEmissionEnergy  1.0*eV
ReflectionCoefficient  0.0
InitDens 0.5e8*cm^-3
DiffCoef {
    TypeConstant_DN
    DN  6.835E6*cm^2*s^-1*Torr/(`kB*0.026*eVT)
    v0  2.3E8*cm*s^-1
}
Mobility {
    TypeConstant_muN
    MuN  6.835E5*Torr*cm^2*V^-1*s^-1/(`kB*0.026*eVT)
    Annotation "15 eV electrons: mu calculated from momentum xfer cross section
3.5E-16 cm2"
}
} # end of SpeciesLis

mdProcessList {
    EnergyLoss {
        TypeEnergyLoss/N(E/N)
        mdLookupTable {
            XMultiplier 1.0*V*cm^-1*Torr^-1*`kB*0.026*eVT
            YMultiplier 1.0*eV*s^-1*Torr^-1*`kB*0.026*eVT
            XYData {
                0  0
                0.5  0
                1  867000
                2  2.66518E6
                3  4.66256E6
                4  6.4869E6
                5  8.7357E6
                6  1.1462E7
                8  1.8743E7
                10  2.8203E7
                12  3.984E7
                15  6.114E7
                20  1.0721E8
                25  1.6698E8
                30  2.3232E8
                40  4.0164E8
                50  6.1438E8
                60  8.469E8
                80  1.3869E9
            }
        }
    }
}

```

100	1.9527E9
120	2.5047E9
140	3.0059E9
160	3.466E9
180	3.865E9
200	4.199E9
220	4.4919E9
240	4.7498E9
260	4.9587E9
280	5.1446E9
300	5.2965E9
320	5.4253E9
340	5.5302E9
360	5.6231E9
380	5.696E9
400	5.682E9
420	5.8256E9
440	5.8539E9
460	5.8913E9
480	5.9175E9
500	5.9251E9
520	5.9243E9
540	5.9566E9
560	5.9627E9
1000	5.96E9

}

Annotation " electron energy loss frequency for elastic collisions 2me/mg x <
momentum transfer cross section x velocity x energy > Values for 0, 0.5 and 1000: 3.295E16 BOLSIG
100% helium (E/p) (eV/s/Torr) "

}

}

Reaction {

Name "e + He <=> e + He*"

Format "e + He <=> e + He*"

Rate {

TypeConverting_K(E/N)

mdLookupTable {

XMultiplicator 1.0*V*cm^-1*Torr^-1*kB*0.026*eVT

YMultiplicator 1.0*cm^3*s^-1

Annotation "": BOLSIG 100%He, E/p (V/cm/Torr) k (cm3/s)"

XYData {

0 0

1.2 0

1.4	1.83E-17
1.6	7.32E-16
1.8	8.52E-15
2	4.64E-14
2.2	1.55E-13
2.4	3.72E-13
2.6	7.16E-13
2.8	1.18E-12
3	1.75E-12
3.2	2.41E-12
3.6	3.93E-12
4	5.64E-12
4.4	7.46E-12
5	1.04E-11
6	1.57E-11
7	2.13E-11
8	2.72E-11
10	3.97E-11
12	5.3E-11
14	6.73E-11
16	8.18E-11
20	1.13E-10
25	1.55E-10
30	1.93E-10
35	2.34E-10
40	2.76E-10
45	3.16E-10
50	3.56E-10
60	4.29E-10
70	4.95E-10
80	5.53E-10
100	6.41E-10
120	6.95E-10
140	7.25E-10
160	7.31E-10
200	7.21E-10
240	6.89E-10
280	6.48E-10
320	6.05E-10
360	5.66E-10
400	5.27E-10
1000	5.27E-10

}

}

```

    }
}

```

```

Reaction {
  Name "e + He* <=> e + e + He+"
  Format "e + He* <=> e + e + He+"
  Rate {
    TypeConverting_K(E/N)
    mdLookupTable {
      XMultiplicator 1.0*V*cm^-1*Torr^-1*kB*0.026*eVT
      YMultiplicator 1.0*cm^3*s^-1
      Annotation "": BOLSIG 100% helium E/p (V/cm/Torr)      k (cm3/s)"
      XYData {
        0  0
        1  2.47E-10
        2  2.53E-8
        3  6.36E-8
        4  7.93E-8
        5  8.67E-8
        6  9.1E-8
        8  9.74E-8
        10 1.02E-7
        15 1.13E-7
        20 1.21E-7
        30 1.36E-7
        40 1.49E-7
        60 1.69E-7
        80 1.84E-7
        100 1.94E-7
        120 2E-7
        160 2.07E-7
        200 2.07E-7
        240 2.04E-7
        300 1.96E-7
        320 1.93E-7
        400 1.82E-7
        560 1.56E-7
        1000 1.56E-7
      }
    }
  }
}

```

```

Reaction {

```

Name "e + He <=> e + e + He+"

Format "e + He <=> e + e + He+"

Rate {

Type Converting_K(E/N)

mdLookupTable {

XMultiplicator $1.0 \cdot V \cdot \text{cm}^{-1} \cdot \text{Torr}^{-1} \cdot \text{kB} \cdot 0.026 \cdot \text{eV}$

YMultiplicator $1.0 \cdot \text{cm}^3 \cdot \text{s}^{-1}$

Annotation "BOLSIG *: 100%He E/p (V/cm/Torr) k (1/s/Torr)"

XYData {

0 0

1.4 0

1.6 5.46E-19

1.8 1.43E-17

2 1.53E-16

2.2 8.59E-16

2.4 3.02E-15

2.6 8.19E-15

2.8 1.82E-14

3 3.46E-14

3.2 5.95E-14

3.4 9.41E-14

3.6 1.41E-13

3.8 2E-13

4 2.73E-13

4.4 4.86E-13

5 9.11E-13

6 1.97E-12

7 3.64E-12

8 5.77E-12

9 8.5E-12

10 1.21E-11

12 2.09E-11

15 3.95E-11

20 8.5E-11

25 1.58E-10

30 2.46E-10

35 3.64E-10

40 5.04E-10

50 8.71E-10

60 1.34E-9

70 1.9E-9

80 2.55E-9

90 3.25E-9

100 4.04E-9

120	5.65E-9
140	7.31E-9
160	9.11E-9
200	1.21E-8
240	1.47E-8
300	1.79E-8
360	2.03E-8
440	2.28E-8
1000	2.28E-8

}

}

}

}

Reaction {

Name "He+ + He + He <=> He2+ + He"

Format "He+ + He + He <=> He2+ + He"

Rate {

Type0

k0 1.1E-31*cm^6*s^-1

Annotation "Johnson R, J. Chem. Phys., US Vol. 73 p1717 (1980): (1.1?.1)E-31 exp. Chatterjee, J. Chem. Phys., US Vol. 93 p.5581 (1990): (0.99?.1)E-31 theor. Boeringer, J. Phys. B., UK Vol.16 p.2619 (1986): 1.35E-31 exp."

}

}

Reaction {

Name "He* + He* <=> He+ + He + e*"

Format "He* + He* <=> He+ + He + e*"

Rate {

Type0

k0 0.87E-9*cm^3*s^-1

Annotation "Stevefelt, J.Chem.Phys., US vol. 76 p.4006 (1982):(2.9?.8)E-9 cm3/s *30% Deloche R, Phys.Rev.A, US vol.13 p.1140 (1976):1.5E-9 cm3/s *30%"

}

}

Reaction {

Name "He* + He* <=> He2+ + e*"

Format "He* + He* <=> He2+ + e*"

Rate {

Type0

k0 2.03E-9*cm^3*s^-1

Annotation "Stevefelt, J.Chem.Phys., US vol. 76 p.4006 (1982):(2.9?.8)E-9

cm3/s *70% Deloche R, Phys.Rev.A, US vol.13 p.1140 (1976):1.5E-9 cm3/s *70%"

```
}  
}
```

Reaction {

Name "He* + e <=> He + e*"

Format "He* + e <=> He + e*"

Rate {

Type0

k0 2.9E-9*cm^3*s^-1

Annotation "Stevefelt, J.Chem.Phys 76 (1982), p.4006."

}

}

Reaction {

Name "He2+ + He <=> He+ + He + He"

Format "He2+ + He <=> He+ + He + He"

Rate {

TypeK(E/N)

mdLookupTable {

XMultiplicator 1.0*V*cm^-1*Torr^-1*kB*0.026*eVT

YMultiplicator 1.0*cm^3*s^-1

Annotation "threshold energy: 10 eV cross section beyond threshold:
1.87E-15 cm2 (hard sphere He-He, lower limit) ion energy distribution: see Hagelaar, Kroesen, and
Klein"

XYData {

0 0

2.57448 0

3.2181 0

3.86172 0

4.50534 0

5.14896 0

5.79258 0

6.4362 0

7.07982 0

7.72344 0

9.97611 1.39E-23

15.12507 1.1E-15

22.5267 7.75E-13

29.92833 6.1E-12

45.0534 3.68E-11

64.362 1.17E-10

96.543 3.01E-10

160.905 7.09E-10

321.81	1.58E-9
643.62	2.83E-9
965.43	3.63E-9

```
}  
}  
}  
}  
}  
}
```

vim: nowrap: