MOHAMMAD MAHDI KHATAMI

ATHENA

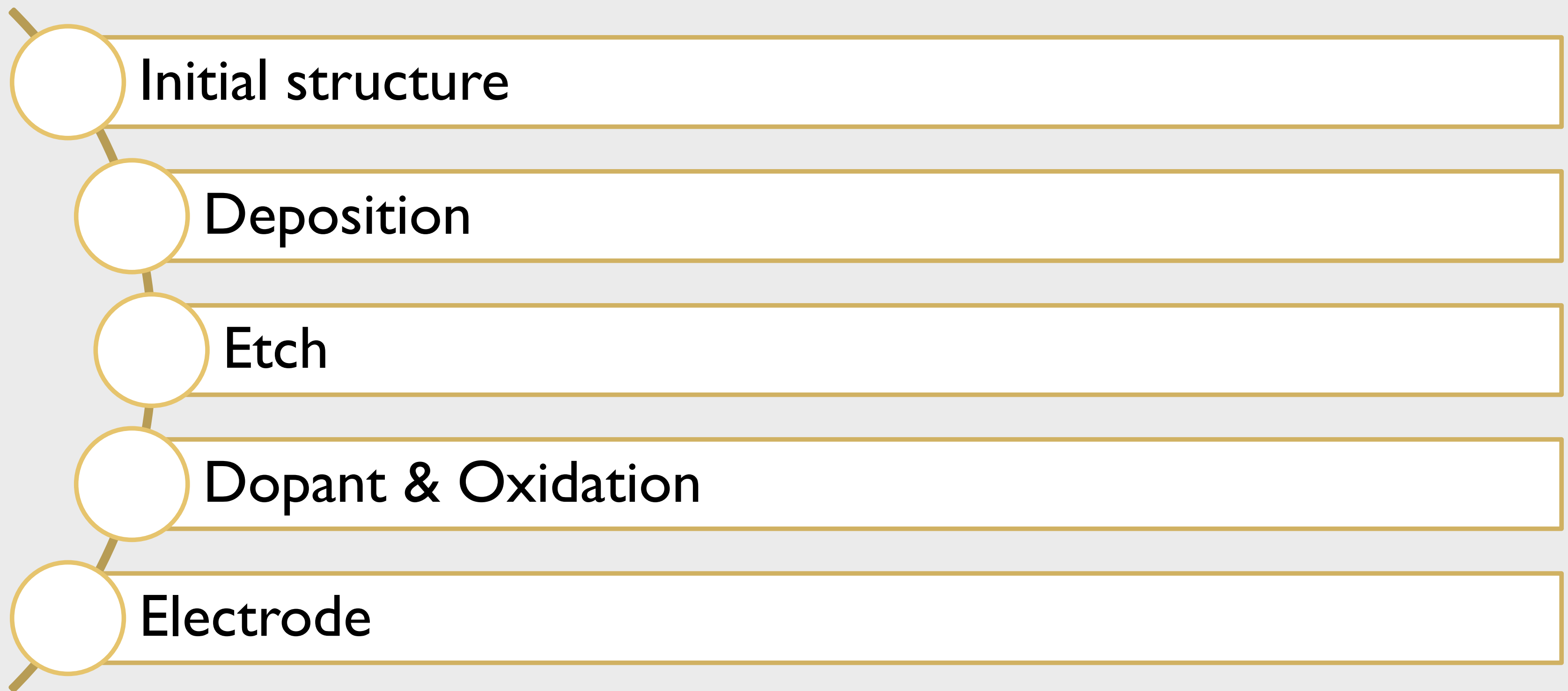
- Numerical, physically-based, 2D simulator of semiconductor processing
- Each ATHENA run inside DECKBUILD should start with:

  go Athena

- Not case sensitive!
- backslash (\) at end of a line means the next line will be interpreted as a continuation of the previous line.
- Comments are indicated by the COMMENT statement or a number sign (#)

mmkhatami@aut.ac.ir, mm.Khatami@modares.ac.ir

STRUCTURE DEFINITION



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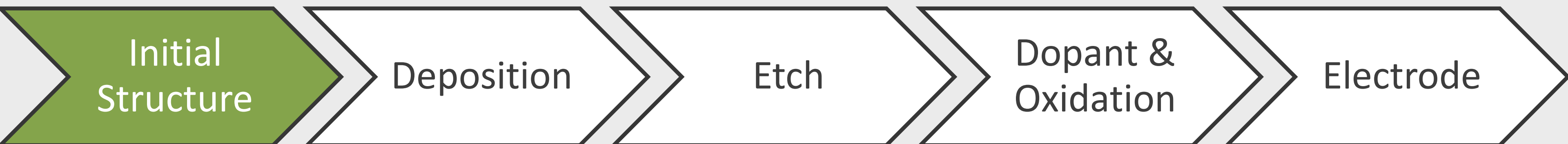
INITIAL STRUCTURE

1. Mesh definition
2. Defining initial structure characteristics



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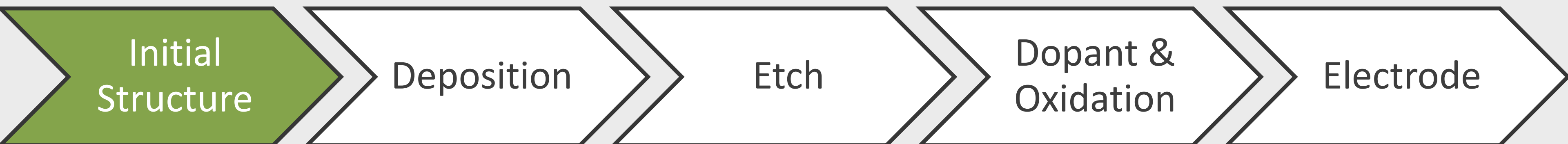
MESH DEFINITION

- Mesh: number of nodes which simulation will be done

1. Mesh size has a direct influence on simulation accuracy and time.
2. A finer grid should exist in those areas where more accuracy is needed e.g. ion implantation, and p-n junction.
3. The maximum number of grid nodes is 20,000 for ATHENA simulations.



mmkhatami@aut.ac.ir, mm.Khatami@modares.ac.ir

MESH DEFINITION

- Example:

LINE X LOC=0.00 SPAC=0.1

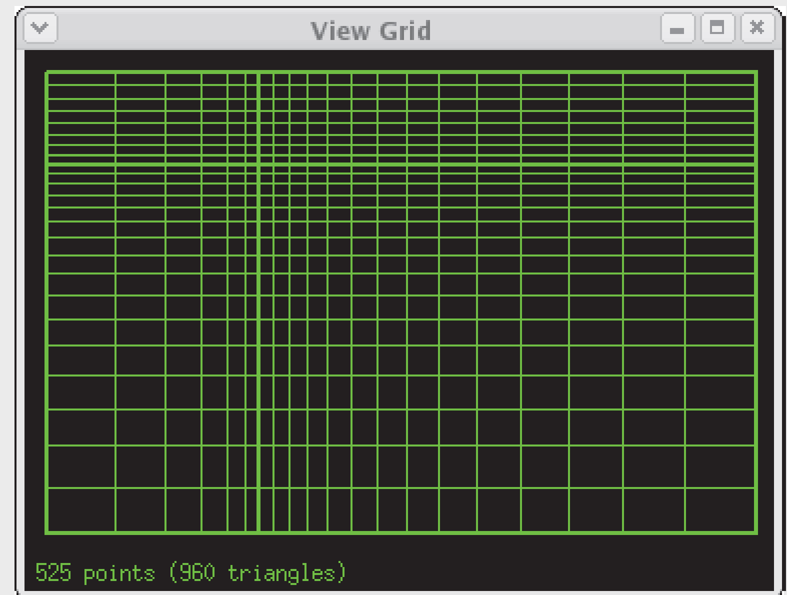
LINE X LOC=0.3 SPAC=0.02

LINE X LOC=1 SPAC=0.1

LINE Y LOC=0.00 SPAC=0.03

LINE Y LOC=0.2 SPAC=0.02

LINE Y LOC=1 SPAC=0.1



Initial Structure → Deposition → Etch → Dopant & Oxidation → Electrode

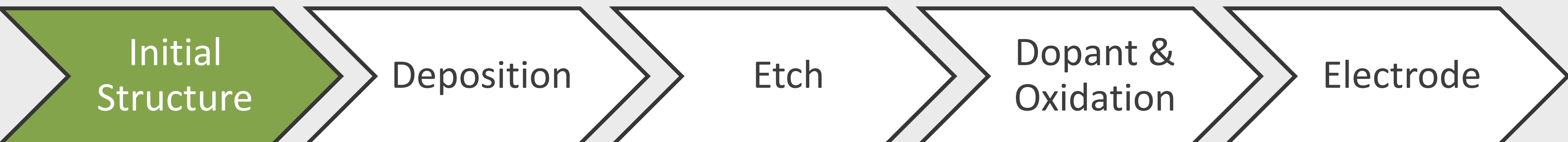
mmkhatami@aut.ac.ir, mm.Khatami@modares.ac.ir

INITIAL STRUCTURE CHARACTERISTICS

- INITIALIZE [MATERIAL] [ORIENTATION=<n>] [X.COMP=<n>] [Y.COMP=<n>] [C.IMPURITIES=<n>]

- Example:

Init Si c.carbon=3.0e14 orientation=100



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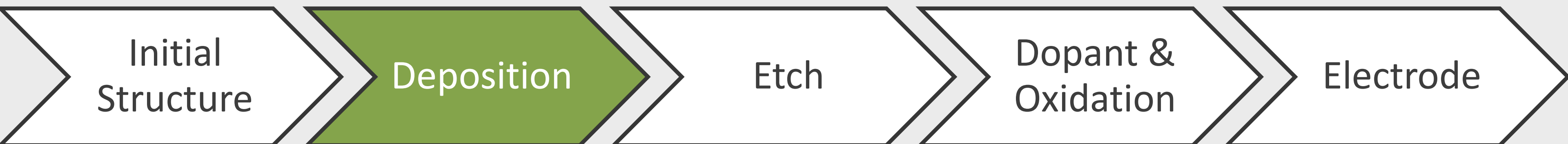
DEPOSITION

- Deposit material thickness=<n> temperature=<n> c.impurities=<n> f.impurites=<n> divisions=<n> x.comp=<n> fx.comp=<n> y.comp=<n> fy.comp=<n>
- **C.IMPURITIES:** concentration of the impurity in the deposited layer
- **F.IMPURITIES:** concentration of the impurity at the top of the layer. When this parameter is used, C.IMPURITY will specify concentration at the bottom of the layer.(graded concentration)



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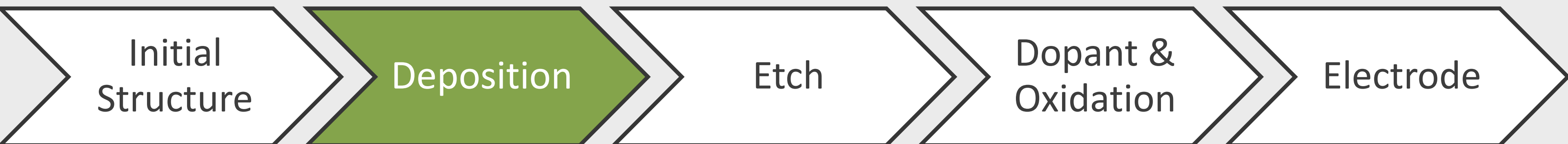
DEPOSITION

- **X.COMP:** composition fraction
- **FX.COMP** composition fraction of the top layer (graded composition). When this parameter is used, X.COMP will specified composition fraction of the bottom layer.
- **DIVISIONS:** number of vertical grid spacings in the layer.



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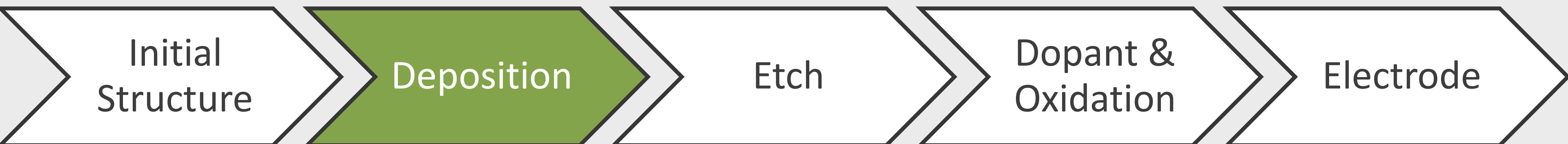
DEPOSITION

- Example:
- deposit silicon c.boron=1e17 thick=0.015 temperature=1000 div=10



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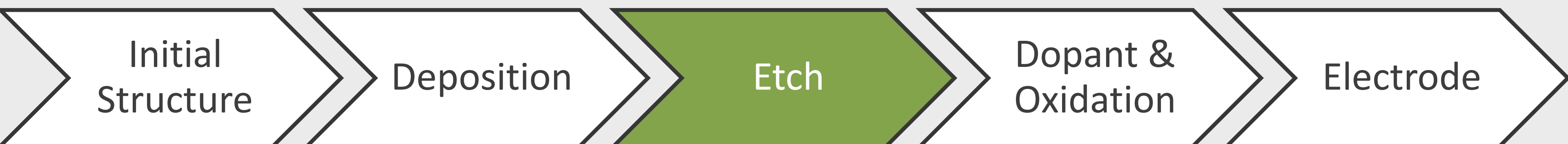
ETCH

- Etch material [all|dry] thickness=<n> [left|right|above|below] p1.x=<n> p1.y=<n> p2.x=<n> p2.y=<n>

- **MATERIAL:** the material to be etched.
- **THICKNESS:** thickness to be etched for the dry etch type.
- **ALL:** that all of the specified materials are removed.
- **P1.X, P1.Y, P2.X,** and **P2.Y:** specify a line for left/right/above/below etching. The P2 parameters are required when the etch angle is non-vertical.



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ETCH

- Example:

etch oxide left p1.x=0 p1.y=-0.1 p2.x=0.05 p2.y=0.01

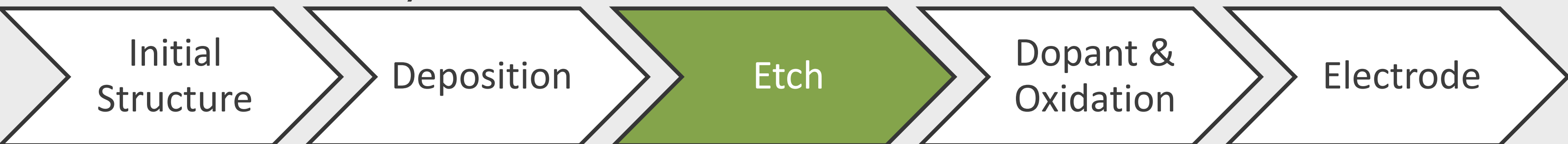
etch dry oxide thickness=0.01

etch oxide start x=0 y=-0.1

etch continue x=0 y=-0.09

etch continue x=0.05 y=-0.09

etch done x=0.05 y=-0.1



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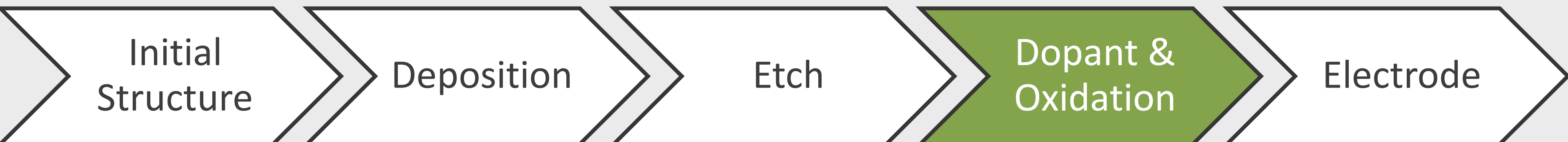
IMPLANTATION

- Implant impurity energy=<n> dose=<n> temperature=<n> [crystal |amorphous]

- **CRYSTAL** and **AMORPHOUS** specify whether or not the silicon lattice structure is to be taken into account during implant steps. CRYSTAL is true by default.
- **DOSE:** dose of the implant. The units are in cm-2.
- **TEMPERATURE:** the temperature of the substrate during implantation.



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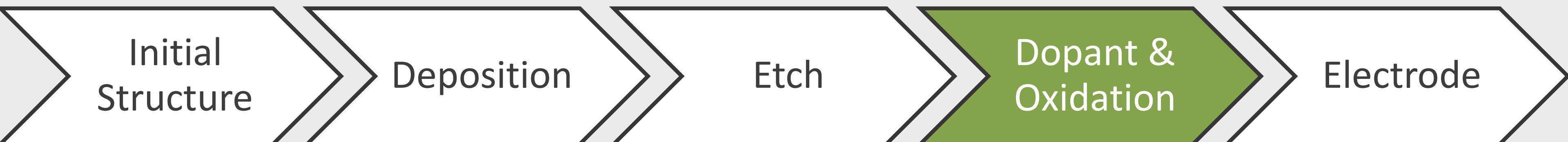
DIFFUSE

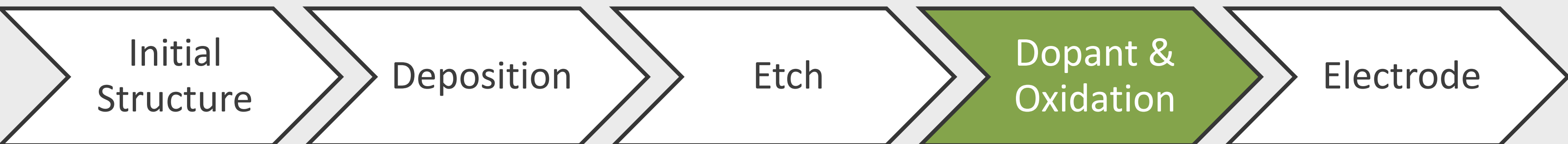
- Diffuse time=<n> [hours|minutes|seconds] c.impurities=<n> temperature=<n> [T.final=<n>] [dryo2|weto2|nitrogen|inert] hcl.pc=<n> pressure=<n>

- **HOURS, MINUTES,** and **SECONDS:** the units of the TIME parameter. Default is MINUTES.
- **DRYO2, WETO2, INERT** and **NITROGEN:** the type of ambient during the diffusion step. DRYO2 specifies that ambient is dry oxygen, WETO2 specifies that ambient is wet oxygen, NITROGEN (or INERT) specifies that ambient is inert.



DIFFUSE

- **TEMPERATURE:** the ambient temperature in °C. (Note that 700<temp<1200, otherwise the simulation results is not trustable. For ramped thermal step, a synonym T.START can be used.
- **T.FINAL:** the final temperature for ramped thermal steps. Synonym is T.STOP.
- **HCL.PC:** the percentage of HCl in the oxidant gas stream.
- **PRESSURE:** the pressure of the active species in atmospheres. The default is 1.



mmkhatami@aut.ac.ir, mm.Khatami@modares.ac.ir

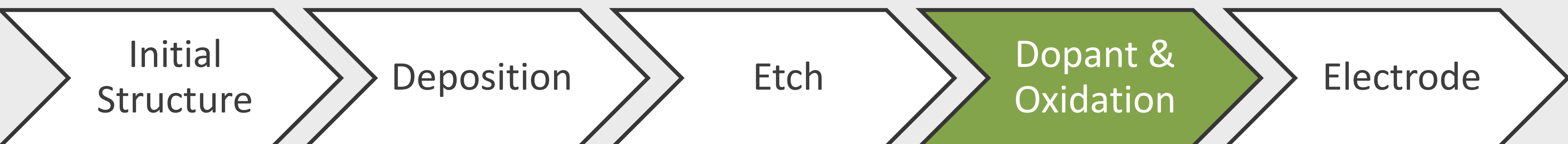
DIFFUSE

- The following statement specifies a 1000°, 30 minute boron pre-deposition.

DIFFUSE TIME=30 TEMP=1000 C.BORON=1.0E20

- The following statement instructs the simulator to grow oxide for 30 minutes in a dry oxygen ambient.

DIFFUSE TIME=30 TEMP=1000 DRYO2



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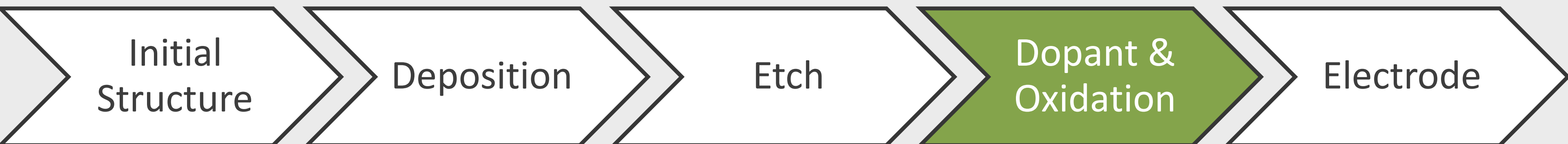
OXIDE

- OXIDE DRY02|WET02 [ORIENT=<n>] [INITIAL=<n>]

- DRYO2, WETO2 specifies the type of oxidation to which specified coefficients apply.
- ORIENT is the substrate orientation. Only 100, 110, and 111 are recognized. The default is 100.



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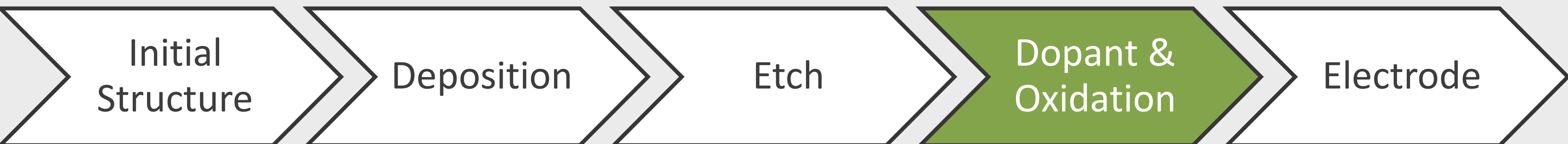
OXIDE

- **INITIAL:** the thickness of the native (initial) oxide at the start of oxidation step. If any oxidizable surface of the structure is bare, an oxide layer of this thickness is deposited before oxidation begins. Units are microns. Default is 0.002.

- The following set the native oxide thickness at 10 Angstroms.

OXIDE INITIAL=0.001



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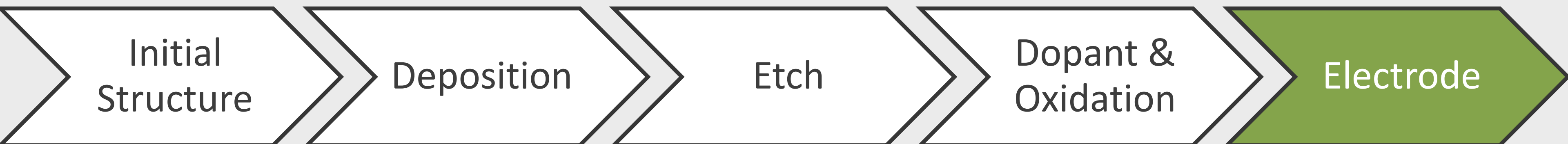
ELECTRODE

- Electrode name=<c> [x=<n> | y=<n> | backside | left | right]

- **NAME** gives a name to the electrode that can be plotted or referenced in TonyPlot or Atlas.
- **BACKSIDE** or **BOTTOM:** a zero height electrode will be placed on the bottom of the structure. (the one exception to whole regions being defined as electrodes). If a metal region is present on the bottom of the structure, this parameter will not be used and the XY coordinates used instead.



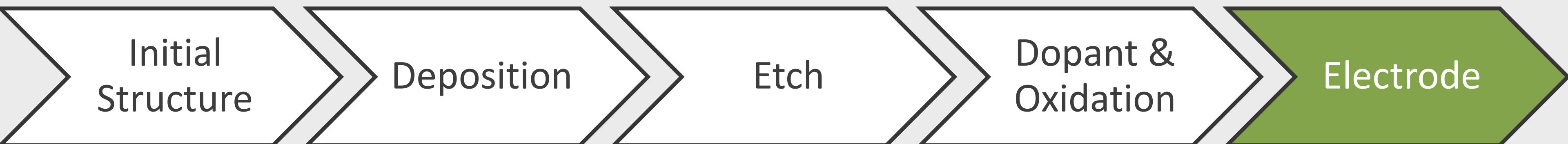
mmkhatami@aut.ac.ir, mm.Khatami@modares.ac.ir

ELECTRODE

- **LEFT/RIGHT:** specifies that the top left/right region of the structure will be defined as an electrode.

- The following gives the name source to the metal or polysilicon region at location x=1 micron on the top of the current structure.

ELECTRODE X=1.0 NAME=SOURCE



mmkhatami@aut.ac.ir, mm.Khatami@modares.ac.ir

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