Dr. Hermann Schlemm
Ion Beam- and Surface Technology
Saalbahnhofstraße 6
D-07743 JENA, Germany
Tel.: ++ 49 3641 22 73 29
Fax: ++ 49 3641 22 87 60
email: hermann.schlemm@jenion.de
http://www.jenion.de

JENION

Material Technology by New Plasma- and Ion Beam Techniques

Research and Development for Thin Film Technology

1 Technique and technology development for thin film processes with plasma- and ion sources

Beside the more or less classical thin film techniques basing only on thermal methods like CVD or thermal or electron beam evaporation a lot of nonthermal thin film deposition methods with thermal activation in combination with nonthermal plasma- or ion beam processes have been developed in the past twenty years. Methods like:

- Ion Beam Assisted Deposition (IBAD),
- Direct Ion beam Sputtering (DIBS),
- Reactive Ion Beam Etching (RIBE);
- Chemical Assisted Ion beam Etching (CAIBE);
- Plasma Enhanced CVD (PE-CVD),
- Plasma Etching,
- Reactive Ion Etching (RIE),
- Plasma polymerization,
- e.t.c,

are well known and developed for many thin film systems.


Fig.1: Plasma- and ion source development laboratory

But moreover new technical and technological demands from industries like semiconductor industry, optical layers, microsystems or hard coatings industry lead to:

a) Application of well known plasma- or ion beam methods (like above sketched) to new thin film systems,
b) Development of new equipment specialized for only one thin film system but that with high industrial productivity and quality,
c) Demands to plasma- and ion beam parameters outside the current known parameter fields (higher charge carrier densities, higher deposition rates, new higher excited plasma states e.t.c.).

However JENION is a small company, a lot of activities are undertaken in this field leading to customer specified equipment- or technological solutions. The following chapters show some of this activities as examples.

Additional developments are carried out for development of special vacuum equipment like special substrate holders [13] , heaters [14] or other customer specialised equipment.

2 Available equipment and processes

Beside the development and production of plasma- and ion sources, special research with these sources can be done at our laboratory (fig.1). Together with plasma probes and plasma probe arrays [11] the plasmas and ion beams used for thin film deposition are analyzed for parameters like ion- and electron density, plasma homogeneity e.t.c. (fig.2, fig.3).

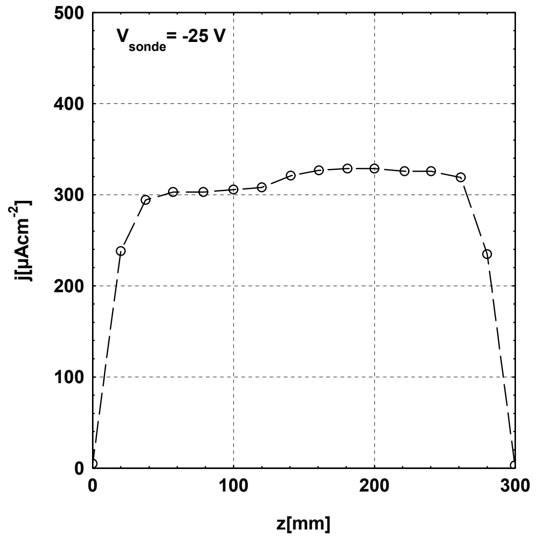

Fig.2: ion current density profile for plasma homogeneity control

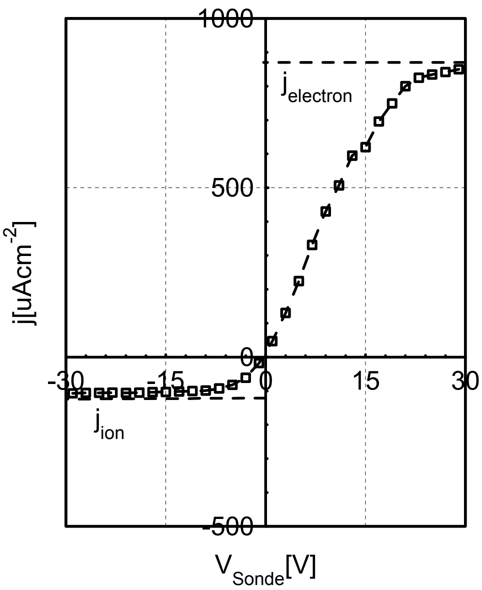

Fig.3: Plasma probe curve for plasma monitoring

At laboratory scale the thin film processes shown at tab.1 are available for most thin film systems.

	thermal processes	**plasma processes**	**Ion beam processes**
types:	thermal evaporation, electron beam evaporation,	magnetron sputtering, plasma etching, plasma CVD, plasma surface modification,	Ion beam sputtering, IBAD, ion implantation, ion beam modification, RIBE, DIBD,
thin film systems	Metals, oxides, semiconductors	Metals, oxides, semiconductors, polymers	Metals, oxides, semiconductors
thickness range, parameters	20 nm to 2 µm	20 nm to 2 µm	20 nm to 2 µm

Tab.1: For Research and Development available thin film processes

3. Process Simulation and complete Software solutions

Today a lot of software solutions exist for use in science. Moreover with software packages like MathCAD a lot of special problems can be calculated before use. Fig.4 gives an example for the vapour pressure calculation of a textile large scale substrate at the pump down cycle before plasma treatment.

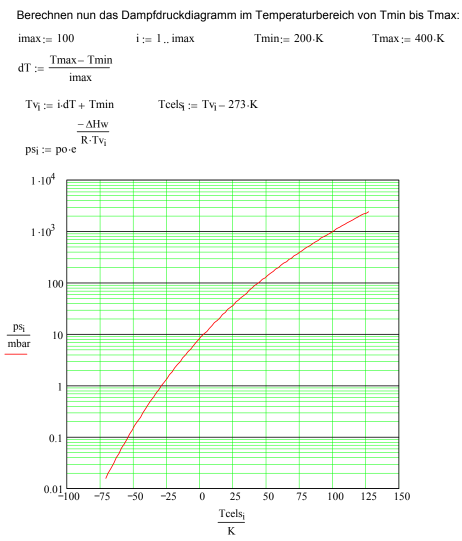

Fig.4: MathCAD simulation of the substrate water pressure in dependence from the substrate temperature of an industrial scale vacuum chamber

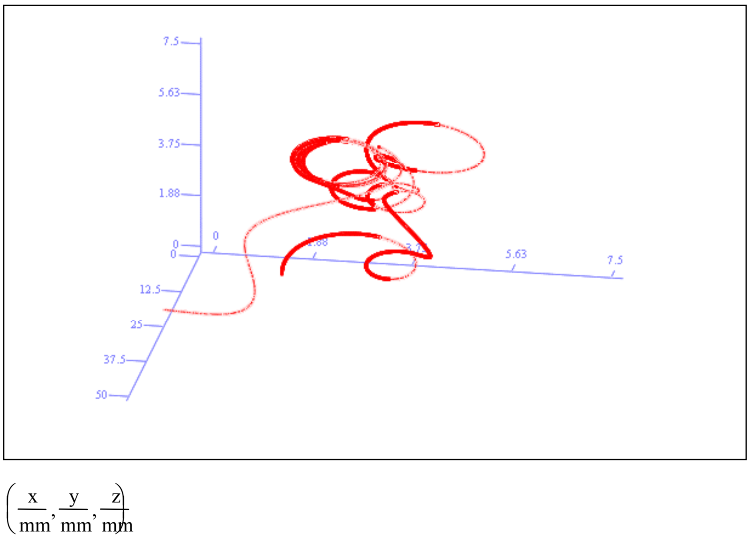

Fig.5: MathCAD simulation of an electron path at a magnetic confined plasma source

Fig.5 shows an electron ray tracing simulation for electrons in an magnetic confined plasma source

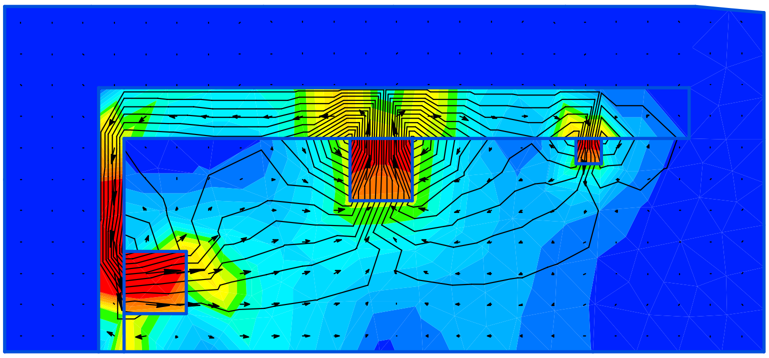

Fig.6: Finite element model of a magnetic field

With the method shown at fig.6 (finite element models) not only magnetic or electrostatic fields used in ion- or plasma sources can be modelled but also heat transfer, thermal induced stress e.t.c.

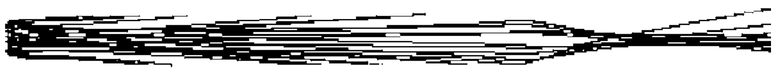

Fig.7: Ion ray tracing simulation of an mass filtered broad ion beam extraction system

Fig.7 shows the ion ray tracing simulation by a special JENION software simulation program for a broad ion beam extraction system consisting of nine grids (mass filtered ion source [1]).

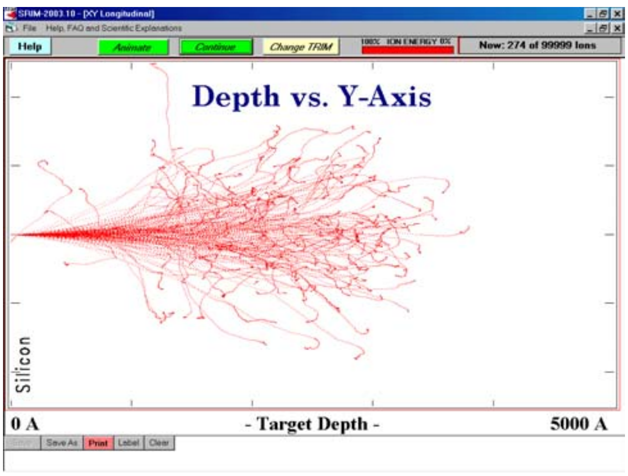

Fig.8: Use of SRIM 2003 [12] for ion implantation simulation of 100 keV O^+ into

Fig.8 shows the use of the ion implantation simulation by SRIM 2003 [12].

silicon

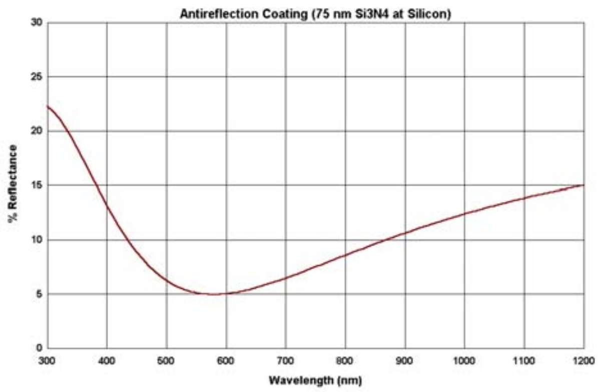

Fig.9: Reflectance simulation of an antireflection coating (75 nm Si_3N_4 on silicon).

At fig.9 the reflection spectra of an antireflection coating is simulated.

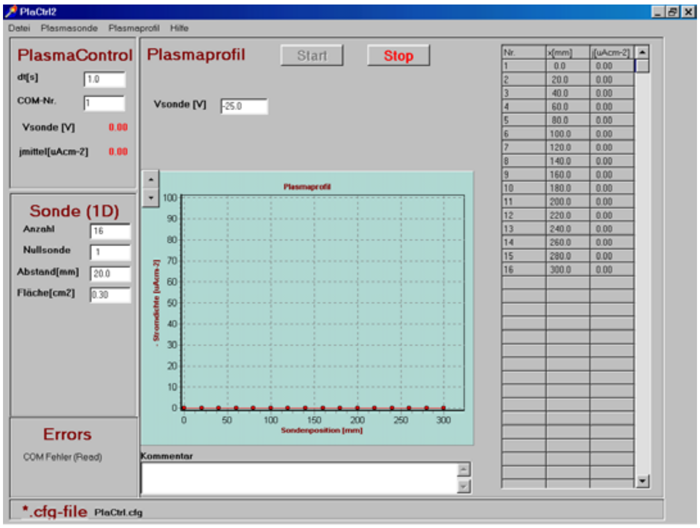

Fig.10: Control software for a plasma probe

Moreover all our devices like ion- or plasma sources have PC-controlled user interfaces like shown at fig.10 and fig.11.

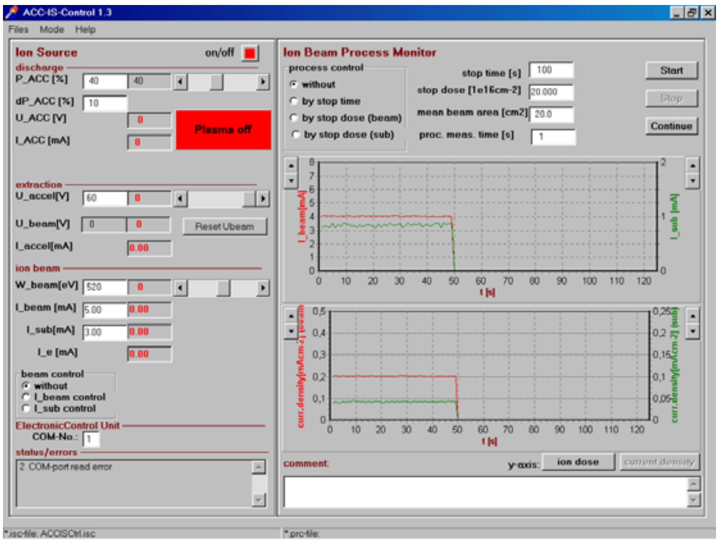

Fig.11: Control software for ion sources together with an ion beam process monitor

4. Thin film deposition and job coating

Most of the above thin film deposition methods also can be used for job coating on a laboratory scale. Series of up to 100 substrates can be processed. The maximum dimension for homogeneous processing is about 100 mm. Because of the possibility to use ion sources in combination with thin film evaporation (like IBAD or ion implantation) our speciality are thin film systems requiring ion beams for reducing inner strength e.t.c.

5. Examples, recent projects

The following projects had been done in the past:

- Ion beam impurity analysis of mass filtered broad ion beams (project with Institute for Surface Modification, Leipzig, www.iom.uni-leipzig.de, [9],1998).
- Reactive ion beam etching (RIBE) of quartz glass with ACC-ion sources, max. etch rate 1µm/min, (contribution to projects at Institute for Surface Modification, Leipzig, 1999).
- Development of microstructured and other electrode systems for plasma generation at high pressure up to atmospheric pressure (contribution to a bmbf-project of Roth&Rau AG, Hohenstein-Ernstthal, www.roth-rau.de, [6,7],1999 – 2001).
- Refinement of microwave plasma sources for use in industrial photovoltaic thin film deposition (contribution to developments of Roth&Rau AG, Hohenstein-Ernstthal www.roth-rau.de, [8], 2000 – 2002),
- Solar cell technology of mc-silicon wafers (contribution to projects of Roth&Rau AG, Hohenstein-Ernstthal [10]), 2001 – 2003),
- Development of a method for two dimensional ion beam profile control for broad ion beams (project together with Institute for Surface Modification, Leipzig, www.iom.uni-leipzig.de, 2001-2003).

6 References

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