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JENION

***Material Technology by New Plasma- and Ion Beam Techniques***

# Application note

# Ion Beam Assisted Deposition (IBAD) with the broad beam ion sources JENION ACC-40 IS or with ACC-30 x 150 IS

## 1 Introduction

For Ion Beam Assisted Deposition an evaporation beam (common from an electron beam evaporator) and an ion beam from an ion source are directed simultaneously to a substrate like shown at fig.1 (see [4 ] and [5]). Metal or oxide targets are placed at the evaporator and used for thin film deposition. The ion beam can be generated from noble gases (like argon – with physical ion influence by ion bombardment) or from gases like nitrogen or oxygen e.t.c. (with additional chemical influence on the layer deposition leading to changed stoechiometry of nitrides or oxides). Details of the IBAD procedure see e.g. [4,5].

JENION manufactures both inline and flange mounted Broad Beam Ion Sources (see [2,6]).
For IAD with JENION Ion Sources see [1] and [3].
For IBAD, like seen from fig.1, inline mounted sources are better suited because of the possibility to mount and to direct the ion beam at best position at the vacuum chamber together with the evaporator.

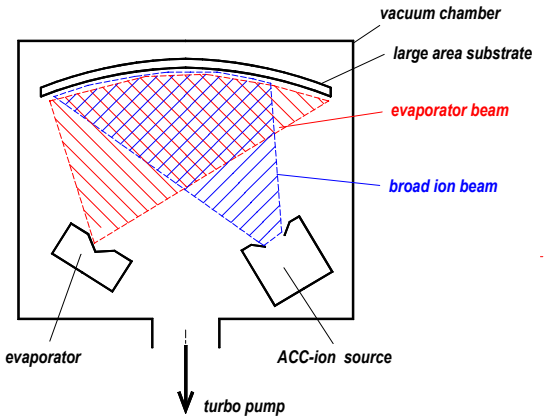


**Fig. 1:** Principle of Ion Beam Assisted Deposition

In principle for IBAD ion energies from some eV to 1000 eV are applied. But for ion energies lower than approx. 100 eV gridless ion sources (plasma sources [1]) are better used and for higher ion energies broad beam ion sources with two extraction grids should be applied. Tab.1 shows the differences of this two energy ranges and the applied sources. The procedure with the ion energy range smaller 100 eV mostly is called Ion Assisted Deposition (IAD) because of the ions direct delivered from the plasma [7].

| | **Ion Assisted Deposition (IAD)** | **Ion Beam Assisted Deposition (IBAD)** |
|---|---|---|
| **Ion energy range** | 10 – 100 eV | 100 – 1000 eV |
| **type of source** | Plasma source | Broad beam ion source |
| **Layer deposition influenced by:** | All generated plasma species (excited neutrals, ions, electrons) | Ions |
| **Typ. growth rates** | 10 – 300 nm/min | 10 – 100 nm/min |
| **Typ. atom/ion ratio** | 10 - 1000 | 100 - $10^4$ |
| **Typical applications** | IAD of optical coatings with defined optical parameters | IBAD of metal, semiconductor or isolating layers with defined compact structure and reduced inner stress |

**Tab.1:** Parameter ranges for Ion Assisted Deposition (IAD) and Ion Beam Assisted Deposition (IBAD)

## 2. Ion Beam Assisted Deposition (IBAD) with ACC-Ion Sources

Fig. 2 shows the principle of the patented [8] ion source. Between three cathodes two further electrodes are arranged powered by a radio-frequency generator (50 kHz). It switches these electrodes between cathode and anode potential so that they act altering as cathodes or anodes at a cold cathode gas discharge. Because of the radio-frequency plasma generation isolating layers on the electrodes do not influence the discharge (like at dc-cold cathode discharges).

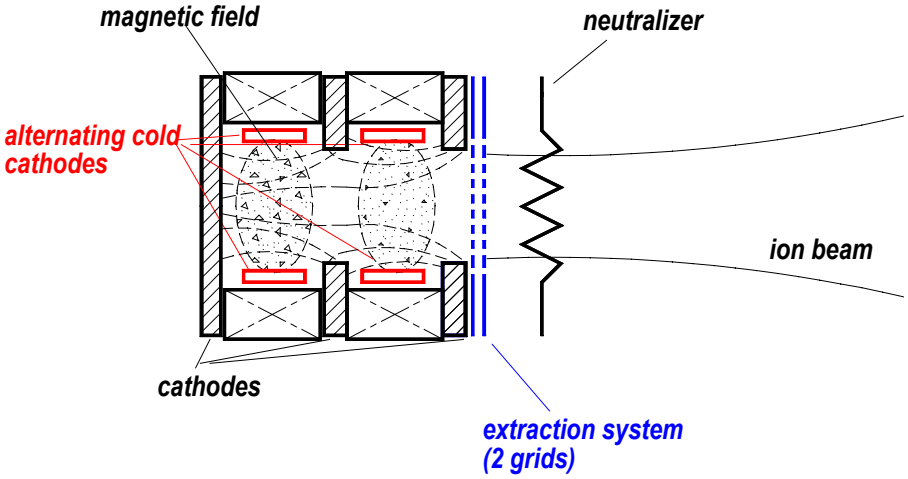


**Fig.2:** Principle of a alternating cold cathode ion source

Two broad beam extraction grids extract the ion beam.
For more details see the ion source product description [2,6].

Fig.3. shows the components necessary for an ion source used for IBAD.

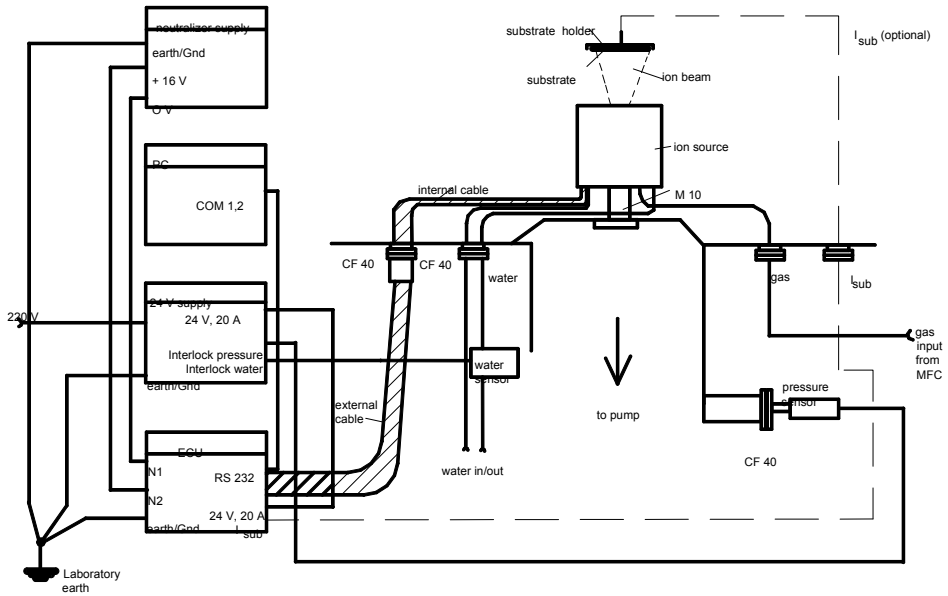


**Fig.3:** ACC-inline mounted ion source for IBAD

The ion source configuration for IBAD is shown at fig.3. It contains the following parts:

**a) ACC-Ion Source:**

Inline mounted ion source with electrical feedthrough from the Electronic Control Unit and feedthroughs for cooling water an gas.

**b) Plasmabridge neutralizer or filament neutralizer (optional):**

The filament neutralizer is part of the ion source. It can be used if necessary (only lifetime problem at oxygen ion beams). Optional an Inline mounted plasma bridge neutralizer with separate electrical and gas feedthrough can be installed.

**c) Electronic Control Unit with Control-PC:**

PC controlled Electronic Control Unit with all power supplies for the ion source.

**d) Neutralizer Supply (optional):**

The filament neutralizer supply consist of a simple and cheap dc-laboratory power supply (16V, 16A, manual controlled). For the plasma bridge neutralizer a special power supply is necessary.

## 3. Typical technical data

Beside the ACC-ion sources of 40 mm diameter also rectangular (linear) dimensions are available. Tab.1 gives an overview about the properties of this sources.

| | **JENION ACC-40 IS** | **JENION ACC-30 x 150 IS** |
|---|---|---|
| **Typical application** | IBAD for research | Special linear ion sources for industrial use |
| **Output diameter** | 40 mm | 30 x 150 mm |
| **Output ion current** | 1 – 20 mA | 5 – 50 mA |
| **Discharge current** | 10 – 100 mA | 0.1 - 0.3 A |
| **Discharge voltage** | 350 - 800 $V_s$ | 350 - 800 $V_s$ |
| **Ion energy** | 100 eV to 1000 eV | 100 eV to 1000 eV |
| **ion current density [mAcm$^{-2}$]** | 0.1 to 1 | 0.1 to 1 |
| **impurities** | 0.05 to 1 % of the plasma current | 0.05 to 1 % of the plasma current |
| **gas flow [sccm]** | 3 - 15 (Ar) | 5 - 30 (Ar) |
| **water flow for cooling [l/min]** | (1 – 5) only for long term use | 1 – 5 |

**Tab.1:** Technical data of the JENION ACC-ion sources

## References


[1] "Plasma sources JENION ACC 40 PS and ACC 80 PS", Product information. JENION 2003.

[2] "Broad beam ion source JENION ACC 40 IS", Product information, JENION 2003.

[3] "Ion Assisted Deposition of optical layers with JENION ACC-Plasma Sources", Application note, JENION 2003.

[4] J.J Cuomo, S.M. Rossnagel, H. Kaufman.
"Handbook of Ion Beam Processing Technology", Noyes Publications, Park Ridge 1989.

[5] T. Itoh (ed.)
" Ion Beam Assisted Film Growth", Vol. 3 of "Beam Modification of Materials" , Elsevier 1989.

[6] "Linear broad beam ion source JENION ACC-30x150 IS, ACC-40x300 IS and ACC-40x600 IS", Product information, JENION 2003.

[7] " Ion Assisted Deposition of optical layers with JENION ACC- Plasma Sources"", Application note, JENION 2003.

[8] H. Schlemm, H. Neumann, Deutsches Patent, DE 199 28 053 A1 (1999).