

HYDROGEN ATOM BEAM SOURCE HABS



HABS 40 on DN40 (O.D. 2.75") CF-flange

The Hydrogen Atom Beam Source HABS is a thermal gas cracker which produces an absolutely ion-free hydrogen gas beam to avoid ion induced damage of the substrate.

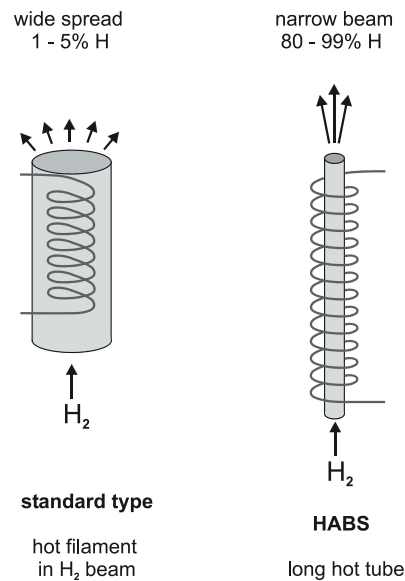
The source was developed by Dr. Karl Georg Tschersich, Institute of Thin Films and Interfaces (ISG), Research Centre Jülich (FZJ) and is excellently characterized. MBE-Komponenten GmbH manufactures the HABS under the licence of the Research Centre Jülich GmbH.

The heart of the HABS is a long tungsten capillary heated with a DC heated surrounding W-filament. Operation temperatures up to 2100°C provide an efficient thermal cracking of H₂ molecules within the capillary. The high purity W-tube is the only part of the HABS with direct contact to the hydrogen gas and forms a narrow angle gas beam ejected from the HABS. The forming of a narrow shaped atomic hydrogen beam results from the long heated area of the W-tube.

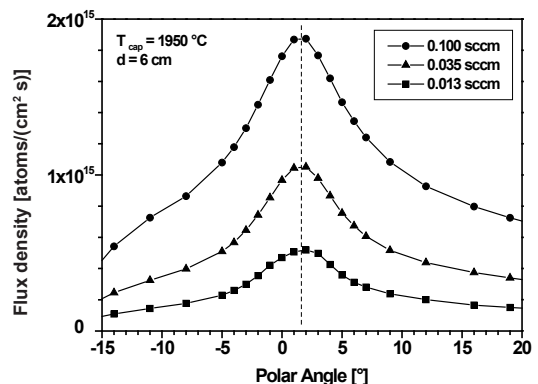
It provides high flux rates at the sample position while keeping the H₂ background pressure of the chamber low – compared to hot filament H-cells and locally heated tungsten tube H-cells.

Despite the high temperatures used for thermal gas cracking, the thermal load of the chamber is low due to the integrated water cooling.

- H₂ dissociation typically 80 to 98% depending on operation conditions
- Atomic H-flux density up to 1*10¹⁶/cm²*s
- No high-energy particles and ions
- Low power consumption (P < 200 W)
- Integrated water cooling, low thermal load on other experimental equipment



Cracking efficiency and principle of standard type hydrogen sources and HABS source by comparison.



Angular distribution of the flux density at a sample positioned 6cm in front of the capillary, adjusted by a mass flow controller.

Application

The use of a narrow tungsten capillary results in a narrow angle distribution of the atomic H-beam (FWHM: 10-20°) which makes the HABS ideally suited for medium and low gas flux applications (up to 1 sccm) and smaller sample sizes or longer substrate distances.

Excellent performance is for example reached for a 1 inch substrate in a typical distance of 100-150mm.

Typical applications for the HABS are low temperature surface cleaning, promotion of 2D growth of GaAs, enhancing of GaN growth rate or H surfactant growth in Si or GaAs MBE.

- Low Temperature Surface Cleaning of InP and GaAs

In MBE the cleaning of substrate surfaces is very important to reach high quality epitaxial films. GaAs or InP substrate wafers can be cleaned while being irradiated with atomic H. Carbon contamination is removed at temperatures as low as about 200°C and oxygen at temperatures of about 400°C.

- Si Substrate Preparation / GaAs on Si

Atomic hydrogen is also used for in-situ cleaning of Si substrates, leading to significant reductions in surface contamination. Atomic hydrogen irradiation has also been used during growth of GaAs on Si substrates to achieve lower defect densities.

- Promotion of 2D Growth of GaAs

Improved properties of MBE grown GaAs are reported after atomic hydrogen enhanced growth, compared to standard grown GaAs.

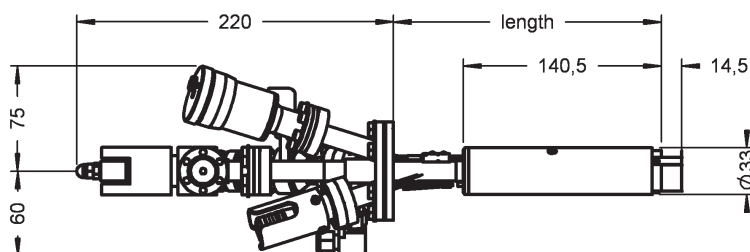
- Selective Epitaxial Growth in MBE and GS MBE

Another feature of atomic hydrogen enhanced MBE growth is selective epitaxial growth. This technique allows a local selective deposition of MBE related materials onto a prepared substrate.

Technical Data

Mounting Flange	DN40CF (O.D.2.75")
Dimensions in Vacuum	190-400mm
Filament type	Tungsten filament
Gas line	Filament heated W capillary
Thermocouple	W5%Re/W26%Re (type C)
Bakeout temperature	300°C
Operating temperature	up to 2100°C
Cooling	integrated water cooling
Options	Aperture (A), integrated Shutter (S)

Schematic drawing of the Hydrogen Atom Beam Source HABS
(Drawing shows HABS 40 with aperture)



References:

- [1] Formation of an atomic hydrogen beam by a hot capillary, K.G. Tschersich and V. von Bonin, J. Appl. Phys. 84, 4065 (1998)
- [2] Intensity of a source of atomic hydrogen based on a hot capillary, K.G. Tschersich, J. Appl. Phys. 87, 2565 (2000)

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