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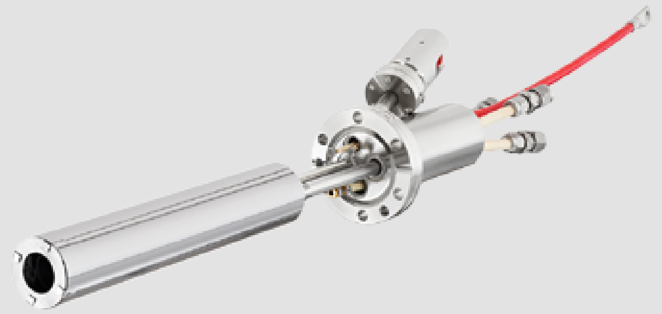
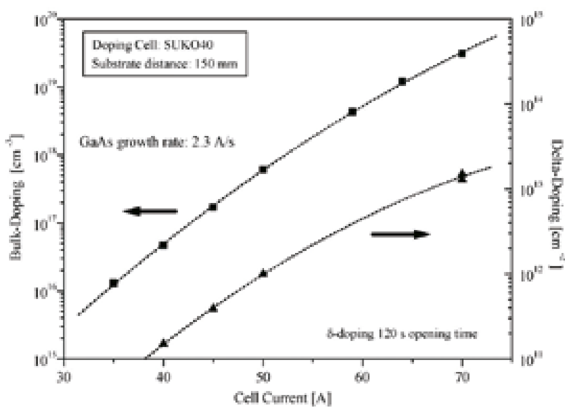
CARBON SUBLIMATION SOURCE SUKO

- Excellent growth of thin carbon films, SiGeC alloys and graphene
- High mobility p-type doping in III-V MBE
- Direct sublimation of high purity carbon filament
- Low power consumption
- No ceramic parts or metal parts close to sublimating filament



SUKO 40 on DN40CF (O.D. 2.75") flange



P-type doping concentration for bulk and delta doping in GaAs as a function of the electrical current of a SUKO 40 [4].

The Carbon Sublimation Source SUKO was developed for growth of Si-C and Si-Ge-C alloys in Si MBE. Providing a very clean and constant flux at a low deposition rate up to 2 Å/min a maximum total layer thickness of 5 μm of C with one filament is achieved. A more recent application of the SUKO is the preparation of high purity graphene layers [7].

The new SUKO-D version is an optimized doping source for carbon p-type doping in III-V MBE. It has been carefully redesigned for low power consumption in collaboration with Prof. W. Wegscheider, formerly University of Regensburg. Please see doping applications and references for details.

Front view of hot carbon filament (operation after removal of orifice plate)

Sublimation of carbon requires very high temperatures up to 2300°C. The majority of other carbon doping cells are built with tantalum, molybdenum, tungsten, or ceramic parts in the hot zone. These materials will generate CO and other undesirable residual gases when used in the hottest area.
Using the SUKO these effects are almost entirely eliminated. Its design is complemented by the exclusive use of low porosity, high purity pyrolytic graphite (PG) in the hot zone, thus avoiding outgassing of any metal parts. All the hot zone shielding around the filament is manufactured from similar PG material.
The electrical contacts are internally water-cooled, which prevents overheating and allows rapid flux rate changes. Excellent vacuum conditions during the growth process are achieved.

Our SUKO sources are used for growing atomically thin layers of carbon on Si substrates or for growing $Si_{1-x}C_x$ alloy layers in Si MBE, as well as for p-type doping in III-V MBE. The growth of almost defect-free graphene layers with the SUKO has become a very successful application.

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In bulk p-type doping applications the hole mobility turns out to be comparable to mobilities achieved by Be doping. The advantage of C-doping is the lower diffusion of C-atoms compared to Be-atoms. Optical, REM and x-ray studies have all confirmed the excellent morphology of the layers. In contrast to carbon gas sources no interaction with MBE equipment or memory effect is observed while operating the SUKO-D. Record hole mobilities in high mobility MBE systems of 1.2×10^6 cm²/Vs in GaAs/AlGaAs hetero structures at a carrier density of 2.3×10^{11} cm^{-2} are confirmed [1].

Achievable doping levels with a SUKO source [2] are:

- P-doping GaAs 6.5×10^{19} cm^{-3}, with a mobility of 29 cm²/Vs (measured at 300 K).
- The maximum bulk doping level of GaAlAs (35% Al, thickness 1500 Å) is 7.5×10^{19} cm^{-3}, with a mobility of 28 cm²/Vs (measured at 300 K)
- The maximum delta doping level in GaAs is 2×10^{13} cm^{-2}.
- Minority carrier lifetime in p-doped GaAs (1.7×10^{19} cm^{-3}) is 140 ps.

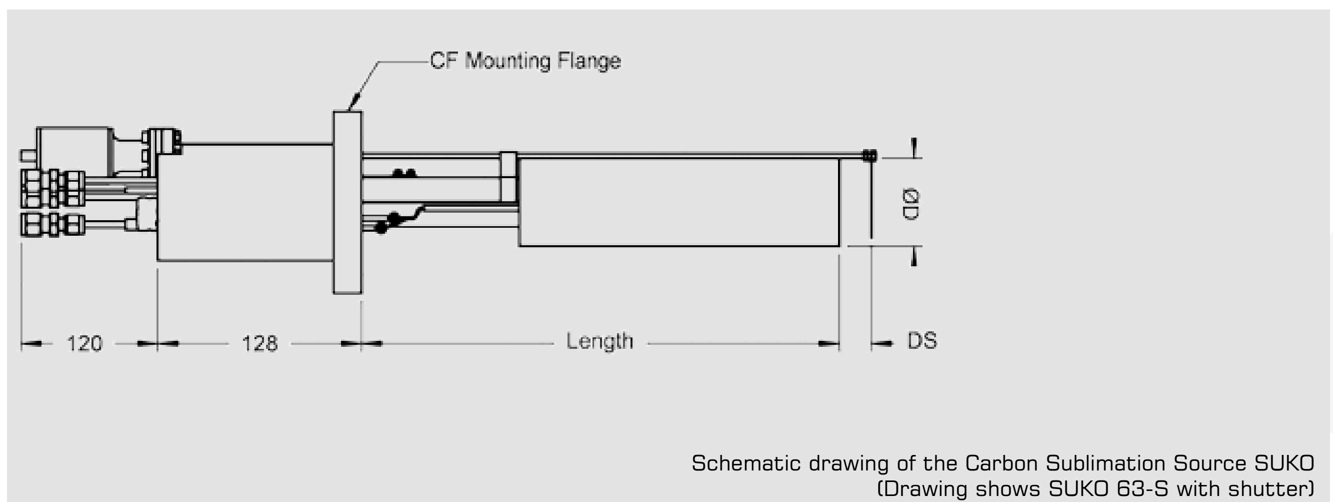
Technical Data

Mounting flange	DN40CF (O.D. 2.75") for SUKO 40 / SUKO-D 40
	DN63CF (O.D. 4.5") for SUKO 63
Dimensions in vacuum	length: 216 - 400 mm; ØD: 36 mm for SUKO 40 / SUKO-D 40
	length: 216 - 400 mm; ØD: 55 mm for SUKO 63
High purity carbon filament	max. current 65 A for C-doping with SUKO-D 40
	max. current 75 A; max flux 0.5 Å/min for SUKO 40
	max. current 100 A; max flux 2 Å/min; for SUKO 63
Thermocouple	W5%Re/W26%Re (type C)
Bakeout temperature	max. 250°C
Cooling	integrated water cooled power contacts
Shutter	integrated rotary shutter (S) (for SUKO 63 only; ØD: 62 mm)

References:

[1] Carbon doped symmetric GaAs/AlGaAs quantum wells with hole mobilities beyond 10^6cm²/Vs; C. Gerl, S. Schmult, H.-P. Tranitz, C.Mitzkus, W. Wegscheider; Appl. Phys. Lett. 86 25,2105; 86 20,2105 (2005)

[2] Heavy carbon doping of GaAs grown by solid source molecular-beam epitaxy; C. Cianni, A. Fischer, C. Lange, K. Ploog and L. Tapfer, Appl. Phys. Lett. (1992) 61, 2 pp 183



Schematic drawing of the Carbon Sublimation Source SUKO
(Drawing shows SUKO 63-S with shutter)

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