



Converted Ultratech Fiji® ALD System at Bilkent University

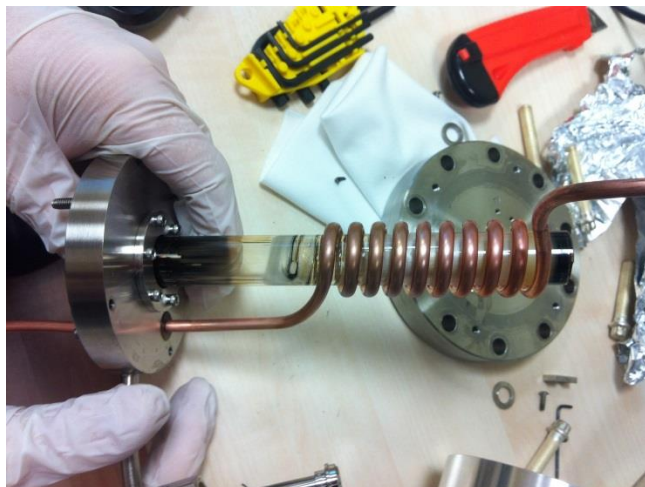
- Reduced oxygen contamination.
- Higher growth per cycle for many material systems.
- Less damage.
- Improved material quality.

## Plasma Source Conversion ICP to Hollow Cathode For Ultratech Inc. Fiji® ALD Systems.

See disclaimer at page bottom

### Why Convert?

Many customers have now approached Meaglow Ltd requesting this conversion. Bilkent University, in Turkey, was the first. Bilkent had identified oxygen contamination in their nitride films was the result of contamination from the ICP plasma source. They had eliminated all other possibilities [1].



They had previously burnt through the quartz lining of their ICP source. After an ICP replacement, manufacturer recommendations reduced oxygen contamination from ~20% to ~5%, but could not achieve any further reduction.

On converting to a Meaglow Hollow Cathode Source, the oxygen content of their films fell below the detection limit of XPS. SIMS indicated levels as low as 0.1% [1]. Much of this residual contamination may have been from atmospheric exposure.



Having lowered the oxygen content of their nitride films, Bilkent University have now been able to achieve device structures at exceptionally low deposition temperatures [2]. To be noted: best results for oxygen reduction are achieved with a load lock in place.

## Other Benefits?

Many of our customers have seen improvement of growth per cycle (GPC), not just for nitrides, but for oxides too. A list of results is provided below. Some of the improvement is due to removal of oxygen contaminants, some is due to lower damage levels. For instance, InN is known to be very damage susceptible [3] so the large improvement in GPC for that material, seems to be partly due to lower damage levels than for the ICP plasma source. Similarly for Al<sub>2</sub>O<sub>3</sub>, for which the improvement can only be due to lower damage levels.

Improvements in crystal structure have also been noted.

Laboratory	Material	ICP GPC	Hollow Cathode GPC
National Taiwan University	Al <sub>2</sub> O <sub>3</sub>	1.0 Å/cycle	1.2 Å/cycle
US Naval Research Labs	InN	0.5 Å/cycle	1.0 Å/cycle
Bilkent University	AlN grown with NH <sub>3</sub> plasma	0.86 Å/cycle	1.02 Å/cycle
Bilkent University	AlN grown with N <sub>2</sub> /H <sub>2</sub> plasma	0.55 Å/cycle	0.96 Å/cycle

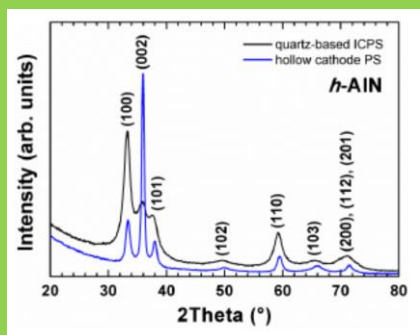
[1] C. Ozgit-Akgun, E. Goldenberg, A. Kemal Okyay and N. Biyikli, J. Mater. Chem. C **2** (2014) 2123.

[2] S. Bolat, C. Ozgit-Akgun, B. Tekcan, N. Biyikli and A. K. Okyay, Appl. Phys. Lett. **104** (2014) 243505.

[3] K. S. A. Butcher, D. Alexandrov, P. Terziyska, V. Georgiev, D. Georgieva and P. W. Binsted, Phys. Stat. Sol. A **209** (2012) 41.



Converted Ultratech Fiji® ALD System at National Taiwan University.



Improvement in crystal structure of Bilkent AlN films.



Oxygen plasma during testing of hollow cathode source for the Ultratech Fiji® ALD System conversion.



Plasma source shown without matching box.



Conversion of Ultratech Savannah® ALD system used for improved oxide deposition.

## Can I use my old matching box?

Yes, Meaglow can carry out the necessary adjustments, or will help you to carry those out yourself. The inductance of the matching box needs to be changed, and there are some adjustments needed for the RF load. The mating of the hollow cathode plasma source and the matching box is carried out with some minor hand machining. There is also some rerouting of water lines. All of this can be carried out by a competent technician.

## I'd like a new matching box. How hard is installation then?

Meaglow can also supply a new matching box pre-mounted to the hollow cathode source. Installation is then virtually a replacement of one source by another.

## Costs? Is it expensive?

No, the Meaglow hollow cathode plasma source is highly cost competitive.

## Can Meaglow convert other ALD systems?

Yes, Meaglow has carried out a number of custom conversions for customers such as the University of Texas (Dallas), ALD Nanosolutions and Georgia State University. We have also recently converted some Ultratech Savannah® ALD systems from thermal to plasma based ALD using hollow cathode plasma sources. We work with customers to achieve the results they want.