

**Metallic, magnetic and
semiconducting nanostructures**

Compound clusters

Catalytic materials

Energetic cluster impact

<1nm to ~10nm clusters

Gas condensation nanocluster sources

High-mass quadrupole

Complete nanocluster deposition systems

Nanocluster Solutions

Metallic, semiconducting and magnetic clusters - Compound clusters

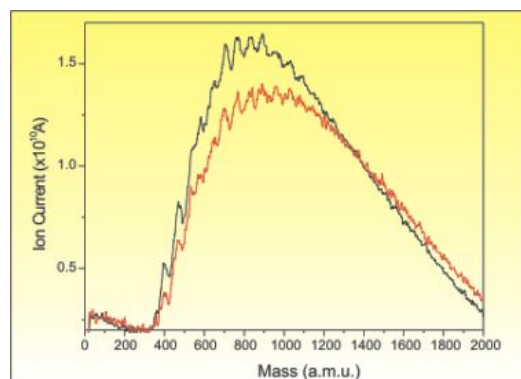
Nanocluster Solutions

Oxford Applied Research supplies a number of products to meet the increasing demands of the nanoscience community. The nanocluster sources can be used to deposit a wide range of clustered materials for applications ranging from research into the fundamental properties of nanoscale structures, to industrial applications such as catalysis and highly adherent films. In addition to the sources we can provide a high-mass quadrupole to measure the cluster mass and size-select the ionised clusters from the source. Furthermore we offer a complete nanocluster deposition system.

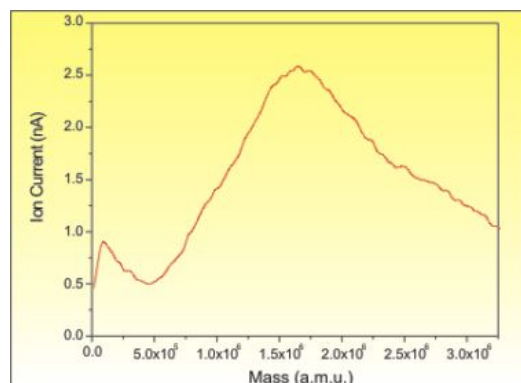
The NC200U nanocluster source is capable of producing beams of well defined nanocrystalline particles using the gas condensation method. The material is sputtered (DC magnetron source) into a liquid nitrogen cooled, high pressure aggregation/ drift region. The clusters form in this region and are then channelled through apertures into the user's system. The source is fully UHV compatible and bakeable. It is efficiently water cooled, has the provision for 3 aggregation gases, and also includes a differential pumping T-piece.

Variable cluster size

The cluster size can be adjusted by varying three main source parameters: the length over which the clusters aggregate (variable using a linear drive), the power to the magnetron and the flow of the aggregation gases. In terms of the cluster size range the magnetron-based source has the advantage over all other types of cluster source as it is the most flexible. For a large number of materials the source is capable of producing clusters consisting of a few tens of atoms up to particles with diameters of around 10nm. Due to the nature of the gas aggregation technique, narrow size distributions can be achieved without the need for further mass-selection.



Small Cu clusters formed using the NC200U. To achieve clusters of this size it is necessary to use a high He flow; a low magnetron power and a short aggregation length. The clusters are less than 30 atoms in size. The spectrum was acquired using the QMF200. Individual atomic peaks can just be resolved at this size regime. The two spectra correspond to He flows of 90sccm (red) and 110sccm (black).

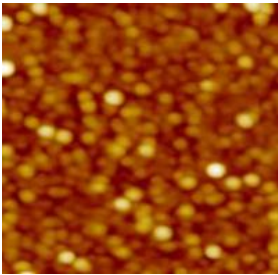


Large Cu clusters formed using the NC200U. For clusters of this size it is necessary to use a low He flow; a high magnetron power and a long aggregation length. The mean cluster size is about 8nm. The spectrum was acquired using the QMF200.

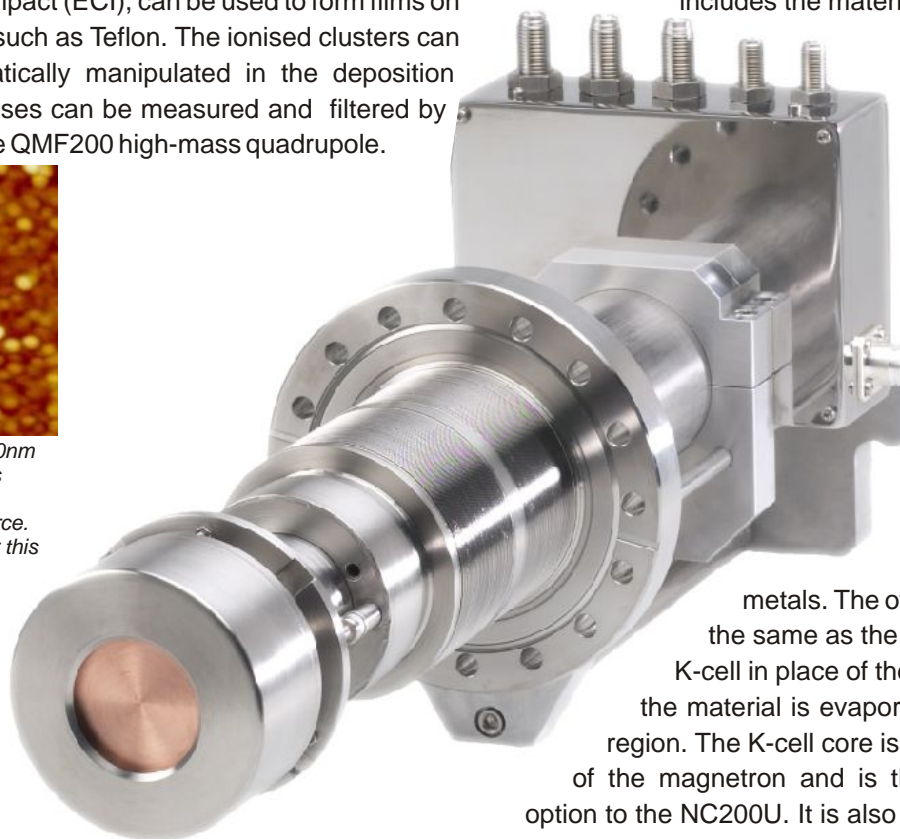
Catalytic materials - Energetic cluster impact - <1nm to ~10nm

High ionised cluster content

A large percentage of the clusters generated by the source are ionised (typically 40% for Cu clusters). An ionised beam can be accelerated towards a substrate to form highly adherent and uniform coatings. This technique, so-called energetic cluster impact (ECI), can be used to form films on difficult materials, such as Teflon. The ionised clusters can also be electrostatically manipulated in the deposition system. Their masses can be measured and filtered by devices such as the QMF200 high-mass quadrupole.



AFM image showing 10nm thick film of Co clusters deposited using the magnetron cluster source. The deposition time for this film was less than a minute.



High deposition rates

The NC200U source is capable of depositing at rates between <math><0.001\text{nm/s}</math> and $>0.5\text{nm/s}$ (measured at a distance of 100mm for Cu clusters). The deposition rate achieved depends on a number of parameters which includes the material and the size of clusters required.

The NC200K K-cell nanocluster source

The NC200K K-cell cluster source allows the deposition of materials which are impossible to deposit with the magnetron-based NC200U source. These include organic materials, metals which are not available as sputter targets, and non-

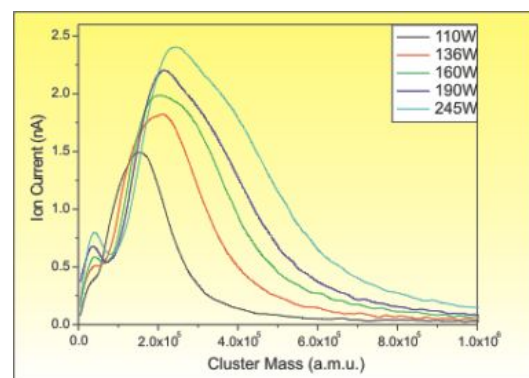
metals. The overall source is essentially the same as the NC200U, although with a K-cell in place of the magnetron. In this case, the material is evaporated into the aggregation region. The K-cell core is interchangeable with that of the magnetron and is therefore available as an option to the NC200U. It is also available as an individual product.

Materials

The NC200U uses standard 2" sputter targets to produce clusters of a number of elements including semiconductors, magnetic materials and most metals. Compound clusters, such as TiO_2 , can also be formed by adding O_2 to the aggregation region during operation.



For standard Fe targets the effect of the magnetron magnetic field is reduced, thus prohibiting sputtering. Oxford Applied Research has teamed up with the UK-based company Gencoa to apply their patent-pending Loop technology to our magnetron design. This exploits the intrinsic magnetism of the target material to shape the field lines across the face of the source. This shaping allows a more uniform sputtering pattern to be achieved, greatly enhancing both the rate of cluster deposition and target utilisation as well as enabling the use of thicker targets.



Fe clusters formed using the NC200U with a Gencoa-designed target. The effect of the cluster size on the magnetron power can be observed (a mean cluster size between 4 and 5nm in this example). The spectrum was acquired using the QMF200.

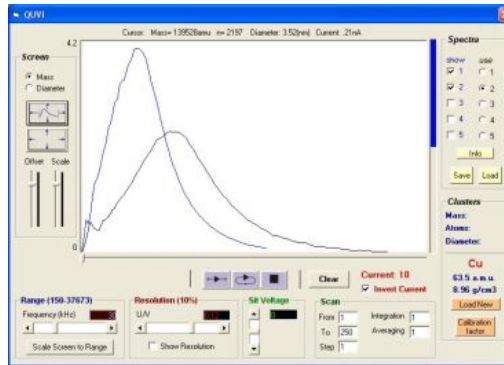
Nanocluster mass analysis and filtering

The QMF200 high-mass quadrupole

Most available quadrupoles (RGA's) are designed to detect the presence of elemental or low-mass species (typically <200amu) and consequently cannot analyse mesoscopic particles. The QMF200 has been specifically designed for the purpose of high-resolution measurement and filtering of nanoclusters between 50 and 3×10^6 a.m.u.

The instrument is compatible with the NC200U nanocluster source for a large number of materials. It can also be tailored to suit home-made nanocluster deposition systems. The quadrupole is available with or without housing and is best positioned directly beyond the source for measurement and filtering. The QMF200 utilises the high ionised content of clusters generated by the NC200U to achieve a high transmission and to acquire clear mass spectra. If required, the ionised clusters can be filtered and steered away from the central un-ionised beam by using steering plates incorporated into the assembly.

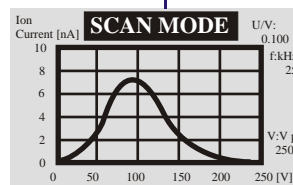
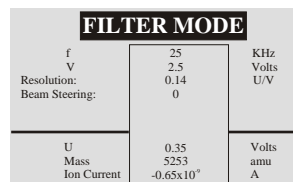
The quadrupole is ruggedly designed and, together with the NC200U source, can be baked to 200°C. The electronics unit allows the user to acquire a mass scan of the clusters from the source and filter the ionised clusters.



QUVI control software

QUVI Quadrupole control software

The QMF200 can be supplied with a comprehensive hardware/software interface to allow full control and data logging from a PC. The accompanying software facilitates analysis of the nanocluster distribution for optimisation of the source parameters; fast data acquisition and, if required, high resolution mass scans.



The QMF200 consists of the quadrupole (left) and power supply unit (above). In addition to a set-up page the PSU has two operational modes for scanning and filtering of the ionised clusters from the cluster source.

Nanocluster Solutions

Nanocluster deposition system



The Nanodep60 nanocluster deposition system

The Nanodep60 nanocluster deposition system from Oxford Applied Research is the first commercially available UHV system designed specifically for the deposition of nanoclusters. It is based around the NC200 nanocluster source and the QMF200 high-mass quadrupole. It is ideally suited to research applications.

The system configuration allows for optimal process flexibility and is tailored for deposition over 1cm^2 substrates. It is suited for soft-landing cluster deposition and optionally for energetic cluster impact studies (a sample manipulator can be incorporated with the ability to electrically bias the substrates). In addition to the NC200U and QMF200, the standard system consists of: a deposition chamber with a number of ports to accommodate other deposition or analytical instruments; a load-lock entry system with sample holder and sample heating; turbo pumping on the chamber and cluster source; gauges, mass flow controllers; gate valves; a quartz crystal deposition rate monitor on a linear drive and all power supplies for system and source control (housed in 2 racks).

Specifications

NC200U Nanocluster Source

Material source	Magnetron
Deposition rate	<0.001nm/s to ~0.5nm/s (for Cu, cluster size dependent)
Mean cluster sizes	<0.4nm to ~10nm in diameter
Ar flow rate required	10-100sccm
Beam diameter	5mm to 40mm at a source-sample distance of 100mm (for Cu)
Aggregation length	Variable
Power supply	1kW supply included
Source mounting	NW150CF or to customer requirement
Water cooling	0.5l/s - de-ionised water advisable
Services	500l/s differential pumping, liq. Nitrogen, Ar and He
Options	Genco Fe targets

QMF200 Quadrupole Mass Filter

Mass range	50 to 3×10^6 a.m.u.
Ultimate resolution	~2% (standard model)
Mounting	In NW150CF tubulation
Options	QUVI Software control

Nanodep60 Nanocluster Deposition System

Cluster source	NC200U (as above)
Mass measurement	QMF200 (as above)
Rate measurement	Quartz crystal monitor on linear drive
Deposition chamber	Base pressure $<1 \times 10^{-9}$. Numerous ports available
Pumping	Turbos with backing pumps. 1000l/s on chamber, 500l/s on source 70l/s on load lock.
Pressure measurement	Ion gauge on system. Pirani gauges on source and backing lines.
Frame	Aluminium support
Electronics	2 racks house system and instrument power supplies
Valves	2 Gate valves (1 on load-lock, 1 to cluster source)
Bake-out	Internal heaters and external band heaters
Sample loading	By load lock
Sample heating	On load-lock arm. To 800°C with PSU
Gas input	2x Mass flow controllers on NC200U with PSU.
Services required	Ar and He gases. Liq N ₂ cooling, water cooling, pump exhaust
Options	As for NC200 and QMF200. Sample manipulator and holder.

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