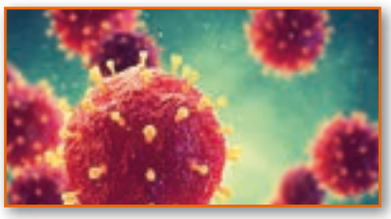
# NL-UHV Nanoparticle Deposition Sources

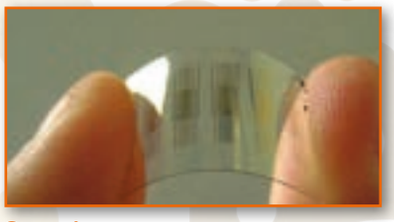
Catalysis


Green Hydrogen



Life Sciences & Nanomedicine

Photonics



Sensing

Nanomaterials for functional coatings

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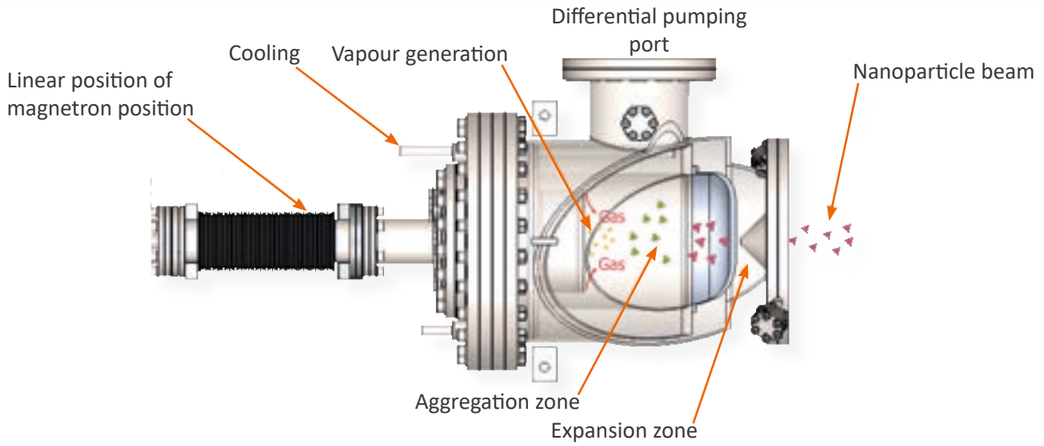
# NL-UHV

## How does this work?

**The NL-UHV series of deposition sources** generates a beam of nanoparticles in vacuum from ultra pure source materials using a combination of plasma assisted sputtering and **gas phase condensation**. A magnetron, mounted on a linear drive, is inserted into the LN2 or water cooled Aggregation zone. Sputter gas is introduced into the Aggregation zone to produce a high pressure (~0.1Torr) and the subsequent application of a dc power to the magnetron generates a plasma. Atoms sputtered from the high purity target enter the high pressure aggregation zone where they quickly thermalize and coalesce to form nanoparticles. The nanoparticle beam is then extracted by the pressure gradient, through the expansion zone and emerges in the deposition chamber.




### Size control

The NL-UHV source produces a distribution of nanoparticles, which can be influenced by the process conditions inside the aggregation zone. By changing the size of the aggregation zone **(insertion length, Lg)**, the Magnetron **Power**, type of P**ower source** (dc or pulsed dc), the Argon **Gas Flow** or by introducing **Helium**, it is possible to tune the distribution of the nanoparticles produced. Helium acts to cool the nanoparticles and thus produces a distribution of smaller nanoparticles. The aperture size at the exit of the expansion zone also affects the nanoparticle size. The NL-UHV is supplied with a selection of interchangeable aperture plates with different aperture sizes. Through varying the process parameters and apertures size nanoparticles with sizes from a few nm to 20nm can be generated. The nanoparticle size can be filtered in flight before reaching the substrate with the NL-QMS mass quadrupole, which can be fitted in-line with the NL-UHV. **To see our NL-QMS brochure** please visit www.nikalyte.com/nl-uhv/.

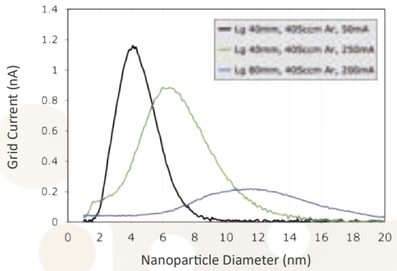



Fig.1. Cu Nanoparticle distribution for varying insertion length (Lg) magnetron Current (mA) and Ar gas flow (Sccm).

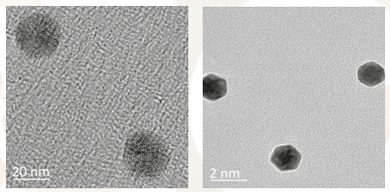



Fig.2. TEM images of Au nanoparticles produced with different process conditions.

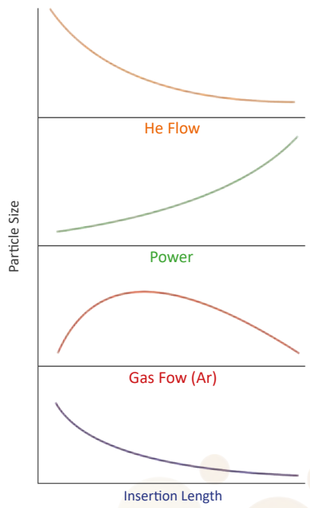



Fig.3. Effect of process parameters on the nanoparticle size.

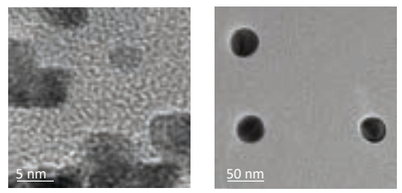
# Overview

### Nanocoating porosity

The NL-UHV generates both charged and neutral nanoparticles, but the larger proportion of nanoparticles carry a negative charge. The charged state of the nanoparticles means that they can be electrostatically manipulated, either through focusing, deflection or acceleration. By applying a positive accelerating bias to the sample the porosity of the deposited nanoparticle layer can be controlled. For a low accelerating bias (~few 100V) the nanoparticles are soft landed and form a highly porous layer. At higher acceleration energies (~1kV) the nanoparticles undergo a small degree of interface mixing and are more adherent to the substrates. At very high acceleration energies the deposited nanoparticle layer reverts to bulk properties and for soft substrates can even undergo implantation into the substrate material. Through control of the accelerating bias and choice of the substrate material a range of different coatings, from soft landed **nanoporous** layers (ideal for delicate substrates, such as polymers and graphene) to **highly adherent** and in some cases **implanted nanoparticle** coatings can be created. Coatings with graded porosity can also be created by varying the accelerating bias throughout the deposition.

### Nanoparticle structure

Nanocoatings are typically three dimensional materials which consist of crystalline or amorphous nanoparticles. The structure of the nanoparticle is heavily influenced by its size due to the strong surface energy compared to 2D or bulk. The dwell time of the nanoparticles in the aggregation zone and the plasma temperature also play a role in formation. Through tuning of the process parameters of magnetron power, aggregation length and gas flows different nanoparticle structures can be formed. The NL-UHV cooling jacket also offers the option to choose between water cooling or LN2 cooling. The use of **LN2** cooling allows extended control over the temperature of the aggregation zone, which can be particularly useful for materials such as Si that nucleate (form nanoparticles) at very low temperatures. LN2 has been shown to increase the deposition rates of Si by several orders of magnitude.




**Effect of bias (5 nm Cu GaAs)**

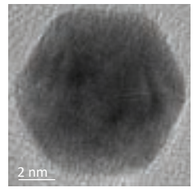




Fig.4. Cubic platinum nanoparticles (top left), spherical silver nanoparticles (top right) and icosahedral gold nanoparticle (bottom).

### Nanocoating density

The loading and distribution of nanoparticles on the surface can be controlled through careful control of the sample surface, nanoparticle landing energy and the deposition time. For low loadings a **monodisperse** coating of equally spaced nanoparticles can be generated. For longer deposition times a 3D nanoporous layer is produced. The loading can be measured using a quartz crystal microbalance to ensure precise and repeatable results for every coating.

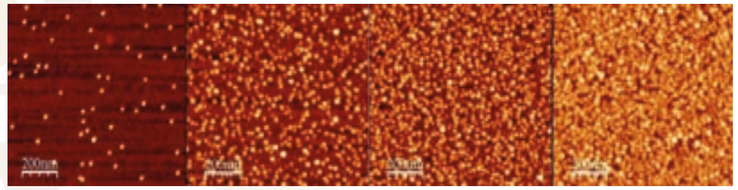


Fig.5. AFM image of Ag nanoparticles with increasing deposition density (left to right).

## Generate and deposit ultra pure nanoparticles directly onto your sample to create functionalized surfaces

# Ultra Pure Nanoparticles

**Alloy and hybrid nanoparticles**

Generating complex nanoparticles such as alloys, core shell and shiners structures with precise control over size, material composition and shell thickness is important for many applications in catalysis, sensing and medical diagnostics. Alloy and hybrid nanoparticles can be generated from a single 2-inch alloy target using the NL-D2 source.

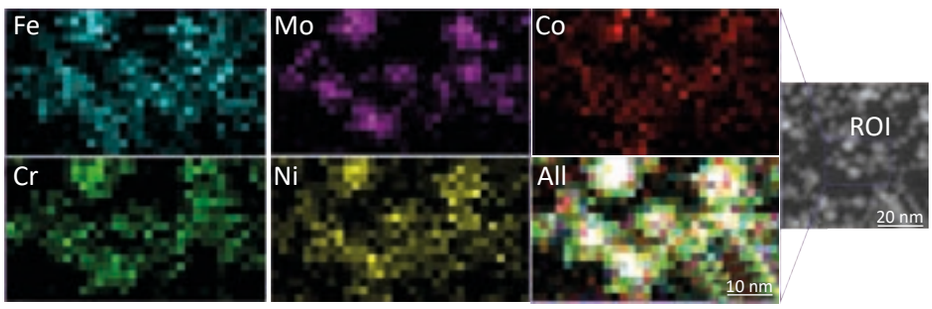



Photo courtesy of Weatherup Group, University of Oxford.

Fig.6. EDS map of NiFeCoMoCr high entropy alloy nanoparticles generated with the NL-D2.

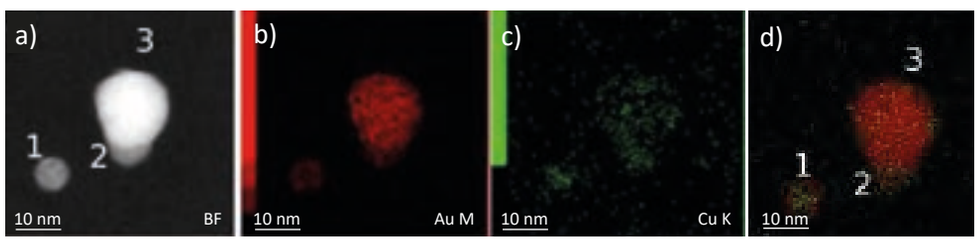
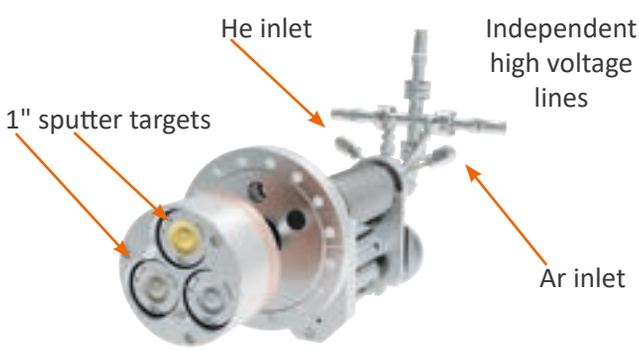



Fig.7. HRTEM and EDX images of Cu-Au nanoparticles generated with the DX3. Bright field image (a), spatial distribution of gold atoms (b), copper atoms (c) combined distribution of gold and copper atoms (d). **J. Phys. Chem. C 2019, 123 (43), 26481.**

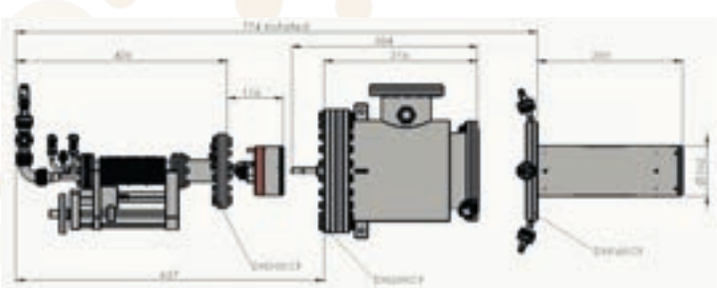
The NL-DX3 triple headed source enables enhanced tuning of alloy composition and nanoparticle structure through the individual control of up to three different target materials. Each target has independent power control and when varied along side other process paraments users can deposit a wide range of alloy and complex structures.

- Independent power control of each target.
- Generate complex alloy nanoparticles.
- Alternate between materials in vacuum.
- dc or pulsed dc operation.




## Specifications

Modular dimensions of the NL-DX3, NL-UHV and NL-QMS. **Please note**: NL-DX3 and NL-UHV dimensions are outside vacuum.



NL-DX3 NL-UHV NL-QMS

| | | | |
|---|---|---|---|
| **Mounting flange** | DN160CF | | |
| **Power** | 630V dc or pulse dc | | |
| **Gas** | Argon/Helium, 2-100 sccm | | |
| **Cooling jacket** | Water or LN2. Flow rate 2L/min (0.52 US GPM) | | |
| **Pumping** | 120L/m (4.2 CFM) backing pump<br>300L/m (10.6 CFM) turbo pump | | |
| **Source options** | NL-D1 | NL-D2 | NL-D3 |
| **Source output** | 75W dc | 100W dc | 3x75W dc |
| **Sputter targets** | 1 x 1" | 1 x 2"<br>0.5 - 3mm thick | 3 x 1" |

For further information please contact: sales@nikalyte.com

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