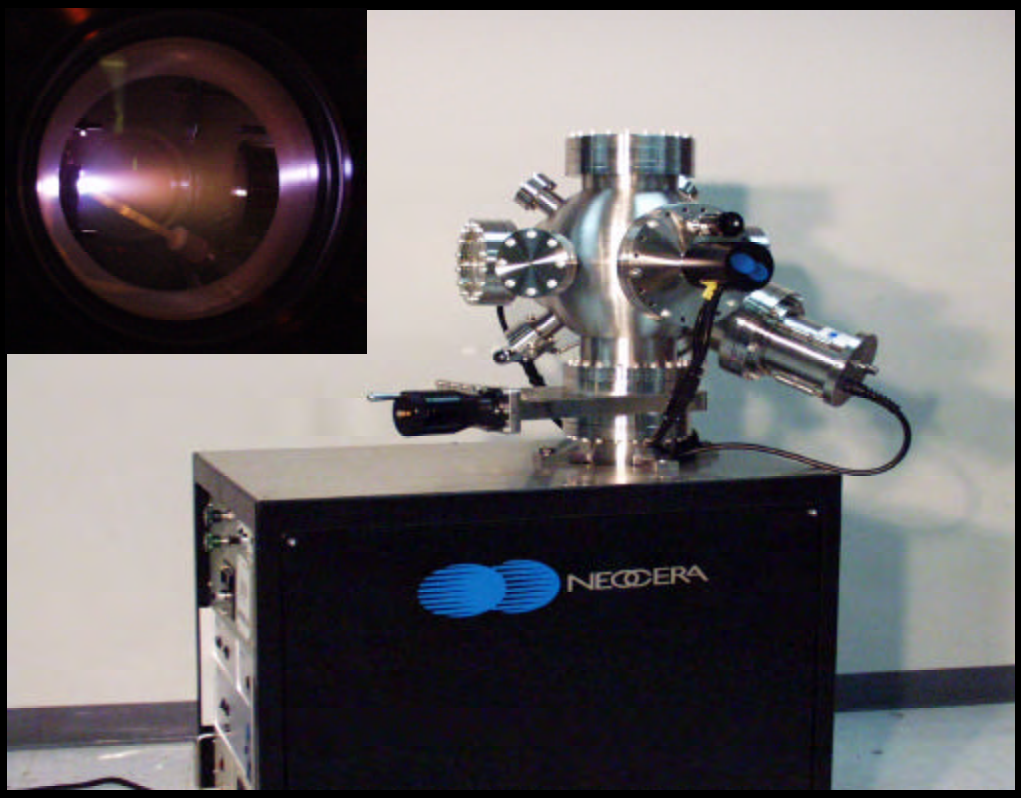
NEOCERA

Pulsed Electron Deposition

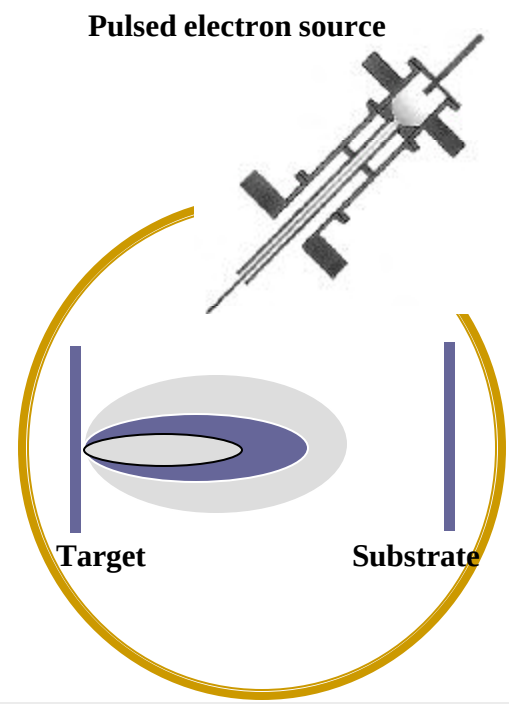


- Suitable for a wide range of materials, including multi-component metal-oxides, complex alloys, and novel polymers
- Non-equilibrium target heating facilitates stoichiometric ablation of target material
- Computer controlled for maximum reproducibility
- Available as turnkey system or electron source package.

Neocera continues to advance the capabilities of pulsed energy deposition techniques through the application and development of pulsed electron deposition.

What is PED?

Pulsed Electron Deposition is a process in which a pulsed (100 ns) high power electron beam (approximately 1000 A, 15 keV) penetrates approximately 1 µm into the target resulting in a rapid evaporation of target material. The non-equilibrium heating of the target facilitates stochiometric ablation of the target material. Under optimum conditions, the target stoichiometry is thus preserved in the deposited films. All solid state materials-metals, semiconductors and insulators, can be deposited as thin films with PED.



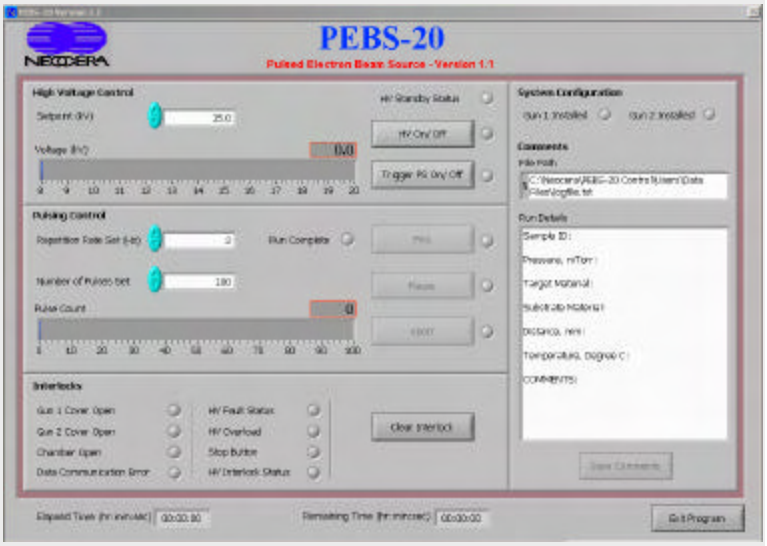
Schematic of pulsed electron deposition

PED's strengths….

In contrast to CW techniques such as conventional e-beam evaporation, the main feature of the pulsed systems is the ability to generate a high power density of ~10^8 W/cm^2 at the target surface. As a result, thermodynamic properties of the target material such as the melting point and specific heat become unimportant for the evaporation process. This is particularly advantageous in the case of complex, multi-component materials. As in the case of Pulsed Laser Deposition (PLD), the Pulsed Electron Deposition (PED) technique provides a unique platform for depositing thin films of complex materials on a variety of technologically important substrates, with a unique strength of extending the range of materials and applications.

Beyond PLD….

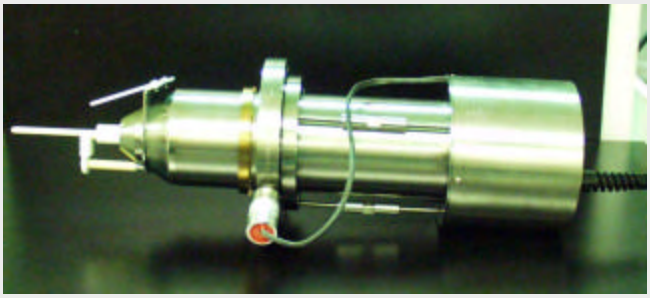
PED technique is expected to extend the range of materials that can be deposited as thin films using pulsed deposition techniques. Unlike PLD, where the ablation process is critically dependent on the optical absorption coefficient of the target material, in PED, the ablation depends only on the range of electrons in the target. For most of the solid state materials, this range is of the order of a few microns. SiO_2 with a large optical band-gap of 10eV for example, is transparent to the 248 nm Kr-F excimer laser radiation. In PED technique however, the high-power electrons can strongly couple to the target material (SiO_2), leading to SiO_2 film deposition. The beam-solid interaction mechanism is quite different in PED in comparison to PLD. This unique difference provides thin film experimentalists a mechanism to extend the parameter-space required for certain novel materials fabrication.



Control Window of Neocera's PEBS-20 pulsed electron source

PED

Neocera offers turnkey pulsed electron deposition systems, and source packages for integration into your existing chamber.



PEBS-20 Pulsed Electron Source

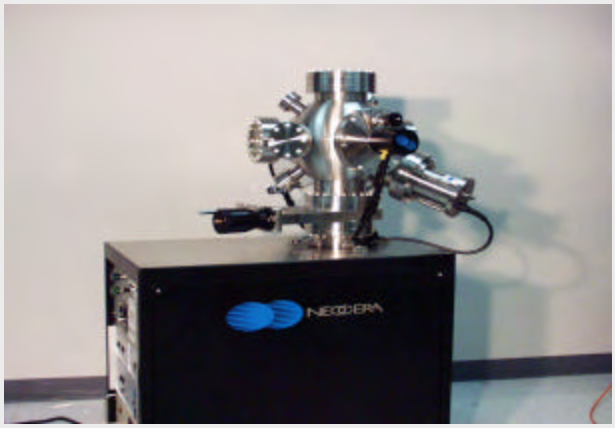
Neocera PEBS-20 pulsed electron source package

Includes:

- PEBS-20 pulsed electron source
- Power supply
- Electronic control package
- Control computer with preinstalled software

Specifications:

Input voltage	115-230 VAC, 50/60 Hz, single phase
Gas pressure, oxygen	5-20 mTorr
Energy of electrons	8-20 kV
Single pulse energy	0.1 – 0.8 J
Pulse energy variation, maximum	±10%
Energy conversion efficiency	25-30%
Pulse width	~100 ns
Pulse repetition rate, maximum	15 Hz
Beam cross section, minimum	6×10^{-2} cm^2
Beam cross section variation, maximum	±20%
Pulse power density, maximum	1.3×10^8 W/cm^2
Z alignment range	50 mm
XY alignment range	±20 mm
Cathode module lifetime	10^7 pulses
Temperature of PEBS body, maximum	85ºC (180ºF)



PED-120 Pulsed Electron Deposition system

PED-120 system specifications

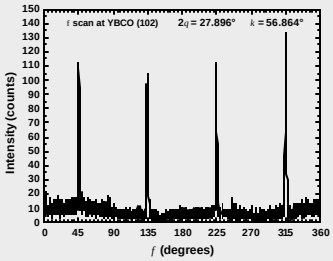
Pulsed electron source and power supply (PEBS-11)

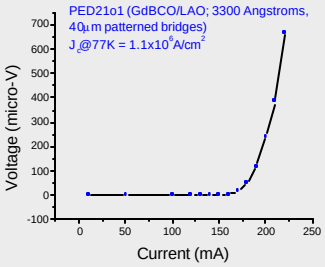
- ❖ Vacuum chamber, 12” diameter
  - ❖ Rated base pressure: <1 x 10^{-6} Torr
- ❖ Substrate heater, 2” diameter with temperature controller
  - ➢ Oxygen compatible to atmospheric pressure oxygen
  - ➢ Maximum temperature: 950ºC
  - ➢ Temperature uniformity: ±5ºC
  - ➢ Temperature stability: ±1ºC
  - ➢ Substrate heater shutter mounted on rotary feedthrough.
- ❖ Target carrousel, manual
  - ➢ Accommodates six 1” diameter or three 2” diameter targets
  - ➢ Target to flange distance: 4”
- ❖ Gas manifold
  - ➢ Mass flow controller for gas inlet into chamber, 100 sccm full scale range
  - ➢ Single channel set/point display module for control
- ❖ Vacuum pumping
  - ➢ 260 l/s turbo/drag high vacuum pump
  - ➢ 4 m^3/hr diaphragm backing/roughing pump (oil-free)
  - ➢ 8” manually actuated gate valve
  - ➢ Purge/vent valve for safe operation with oxygen
- ❖ Pressure gauges, with readouts
  - ➢ Cold Cathode
  - ➢ convection
- ❖ System frame
  - ➢ Footprint: 22”W x 34”D
  - ➢ Clearance: 30”W x 34”D
  - ➢ Overall height: 54-58”
  - ➢ Standard 19” rack mounts for electrical components
  - ➢ Casters and levelers
- ❖ Utility requirements
  - ➢ 110VAC/60 Hz, one 20 amp line

NEOCERA PED

About Neocera PED Technology

Neocera's materials research laboratories continue to expand the capabilities and applications of pulsed electron deposition technology.





PED at Neocera

. High-Temperature Superconducting (HTS) YBCO (and GdBCO) films.
. Metallic-oxide ($SrRuO_3$) films.
. Paraelectric ($SrTiO_3$) films.
. Insulating glass (SiO_2-based) films

Data obtained on YBCO (and GdBCO) films deposited by PED are presented. Films are deposited on single crystalline (100) $LaAlO_3$ substrates. The deposition temperature is 800-850 C. Oxygen partial pressure during deposition is 10-15 mTorr. The film thickness is ~ 3500 Å.

Figure 2 presents AC susceptibility data. The superconducting transition temperature T_c is around 90 K with a transition width ? T_c ~ 1 K. The films are predominantly c-axis oriented and epitaxial with the substrate. X-ray data of **Figure 3** confirms the in-plane epitaxy. The critical current density (**Figure 4**) measured at 77 K, zero field is ~1.1 x 10^6A/cm^2. Figure 5 shows x-ray pole figure data of GdBCO films on biaxially textured RABiTS substrates.
The data presented are good indicators of PED potential in preparing thin films of complex materials. The pulsed nature of the technique preserves the compositional stoichiometry of the deposited thin film. The deposition rate can be controlled to be in the range of 0.5-20 Å/pulse. The technique is scalable and cost effective in high volume manufacturing.

Application support

Neocera will continue to explore the application of PED for materials appropriately suited to its capabilities. Please contact Neocera to request more information on specific materials.

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