Large Area Filtered Plasma Deposition Technology and Applications

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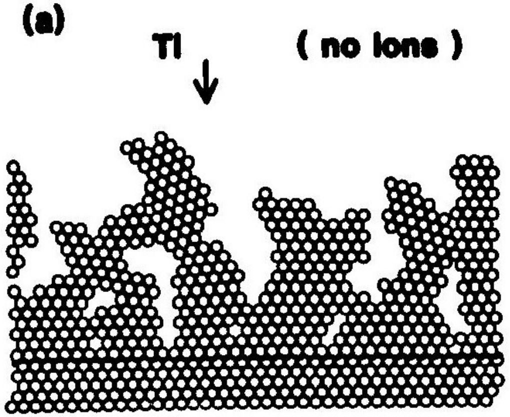
ARCOMAC™ Surface Engineering, LLC

ICMCTF 2007

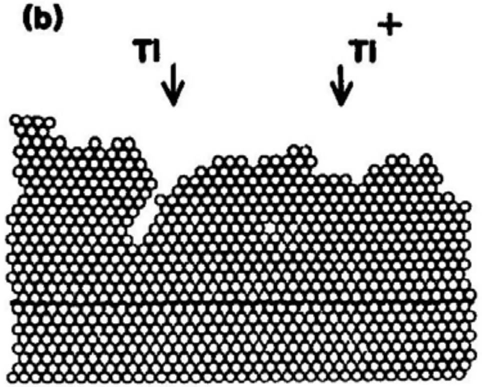
OUTLINE

- **Advantages of ionized deposition**
- **Different technical approaches to ionized deposition**
- **Cathodic arc sources and magnetic steering of arc spots**
- **Pros and cons of conventional cathodic arc deposition technology**
- **Conventional quarter torus and similar FAD sources**
- **How Large Area Filtered Arc Deposition (LAFAD^{TM}) technology works?**
- **Unidirectional dual arc LAFAD^{TM} vapor plasma source**
- **LAFAD^{TM} coating systems**
- **LAFAD^{TM} coatings**
- **Hybrid Filtered Arc Plasma Source Ion Deposition (FAPSID^{TM}) surface engineering technology**

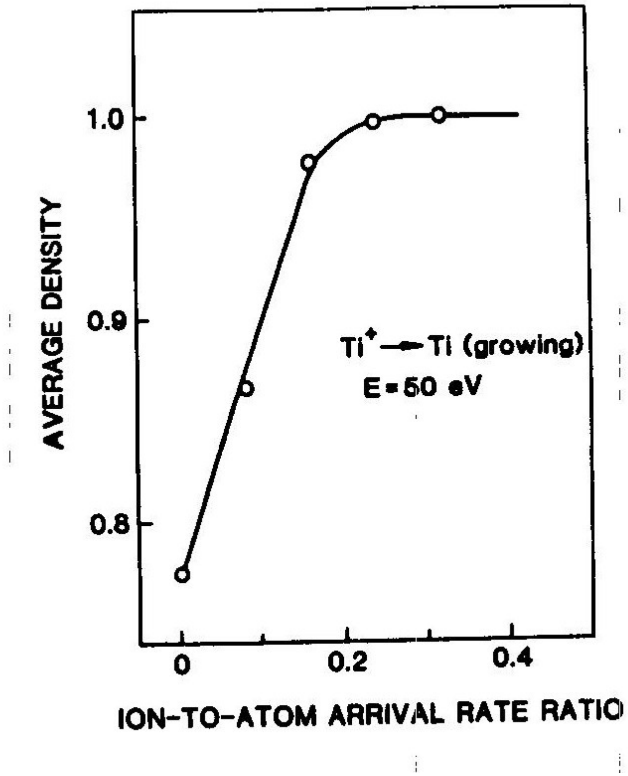
Columnar Growth of (a) Ti film resulting from the deposition of 0.2 eV Ti; (b) Densification resulting from ion-vapor-arrival ratio γ_i=0.2 @ ion energy 50eV; (c) average density of Ti film vs. γ_i (molecular dynamics simulation after P.Martin, 1993)



(a)



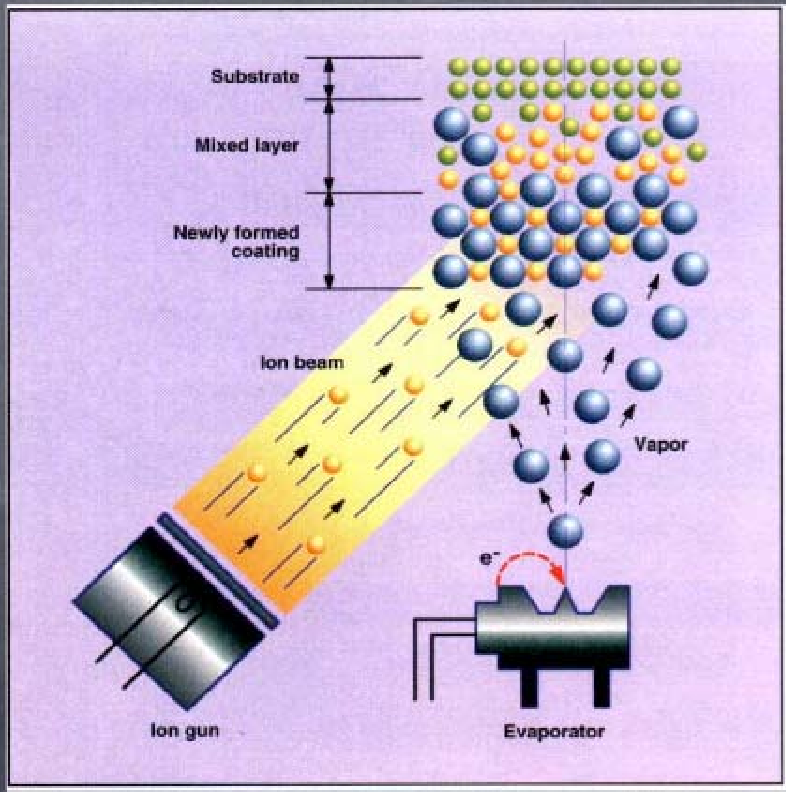
(b)



(c)

Conventional Ion Beam Assisted Deposition

- A line-of-site process
  - Allows deposition of thin coatings



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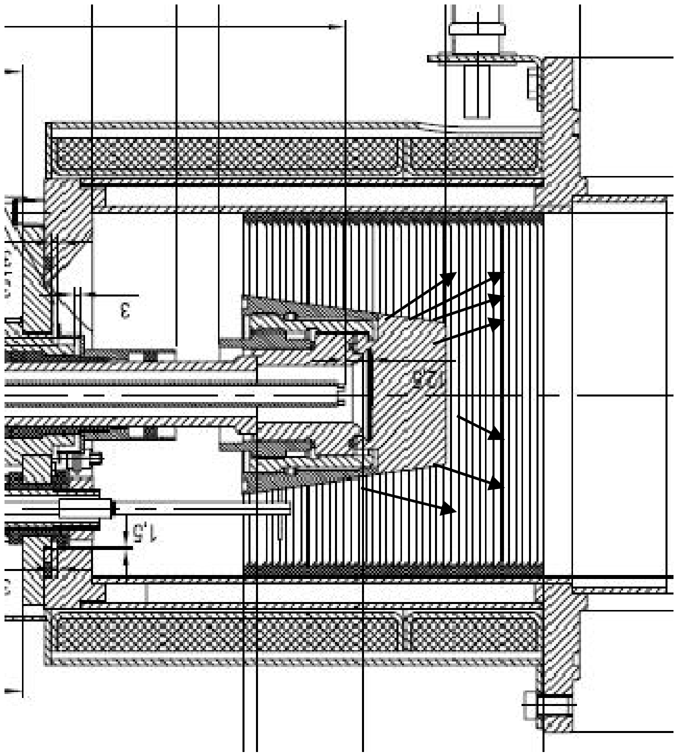
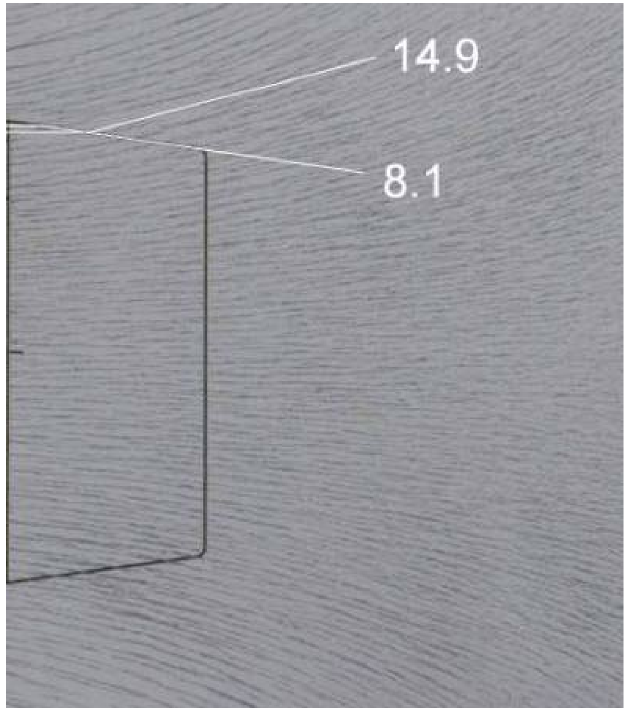
Magnetic steering and cathodic arc sources with cylindrical targets: acute angle rule

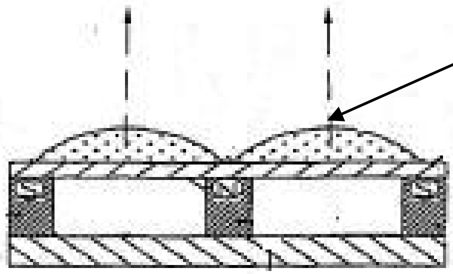




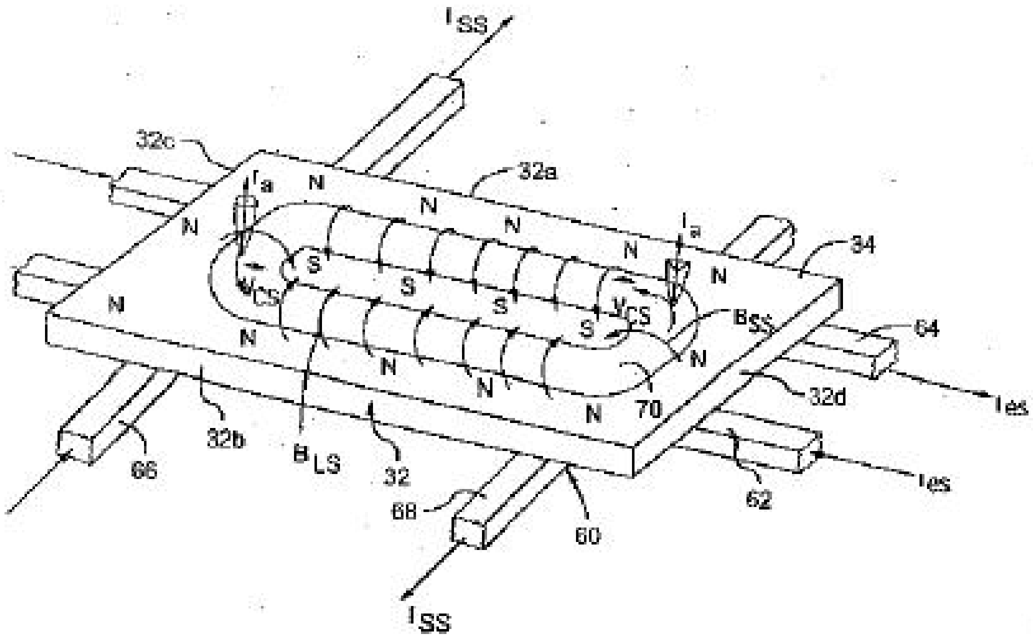
Ti target

Graphite target

Cathodic arc sources with rectangular targets- magnetron style magnetic steering arrangement: close field magnetic arch configuration along the entire arc steering corridor

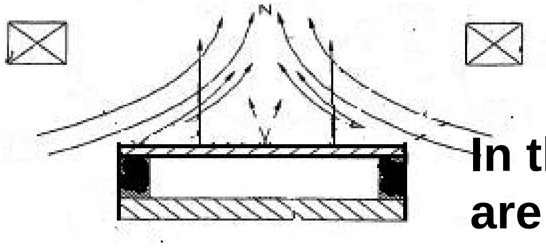


Preferable position of arc spots according to acute angle rule

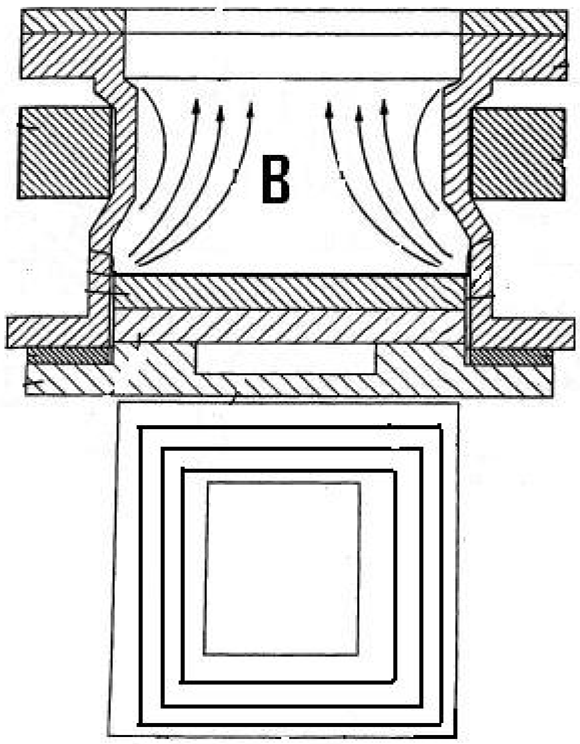


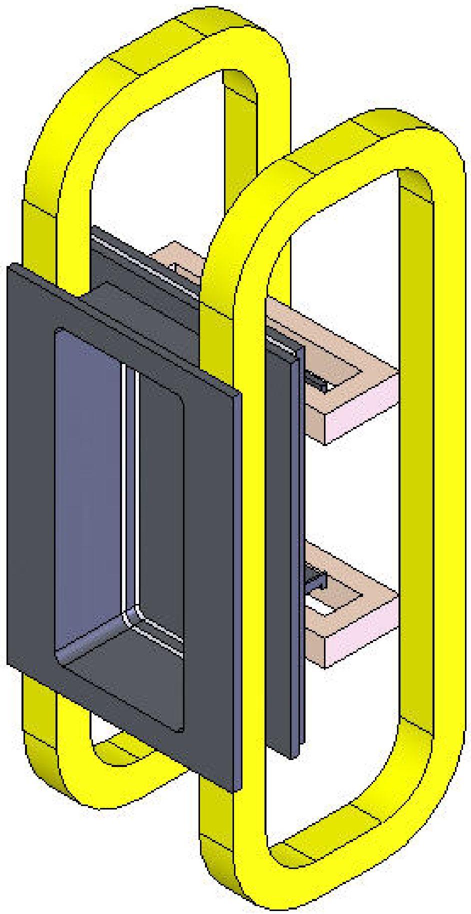
Courtesy of A.Matthews et al.

Cathodic arc sources with split field magnetic steering arrangement: close field arch along short side of the target; open field arch along long side of the target



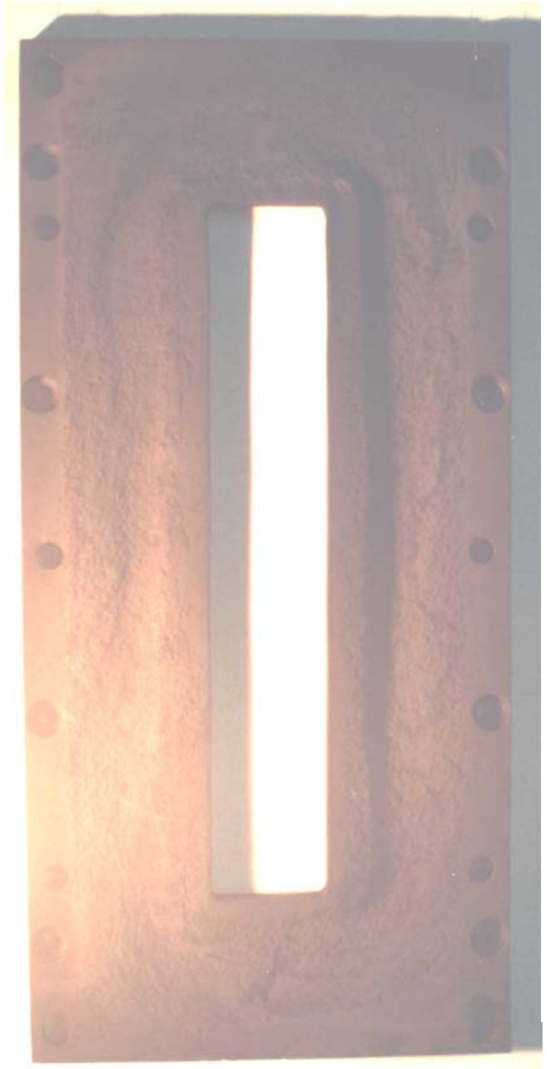
In this design arc spots are moving both along long side of the target and toward center of the target





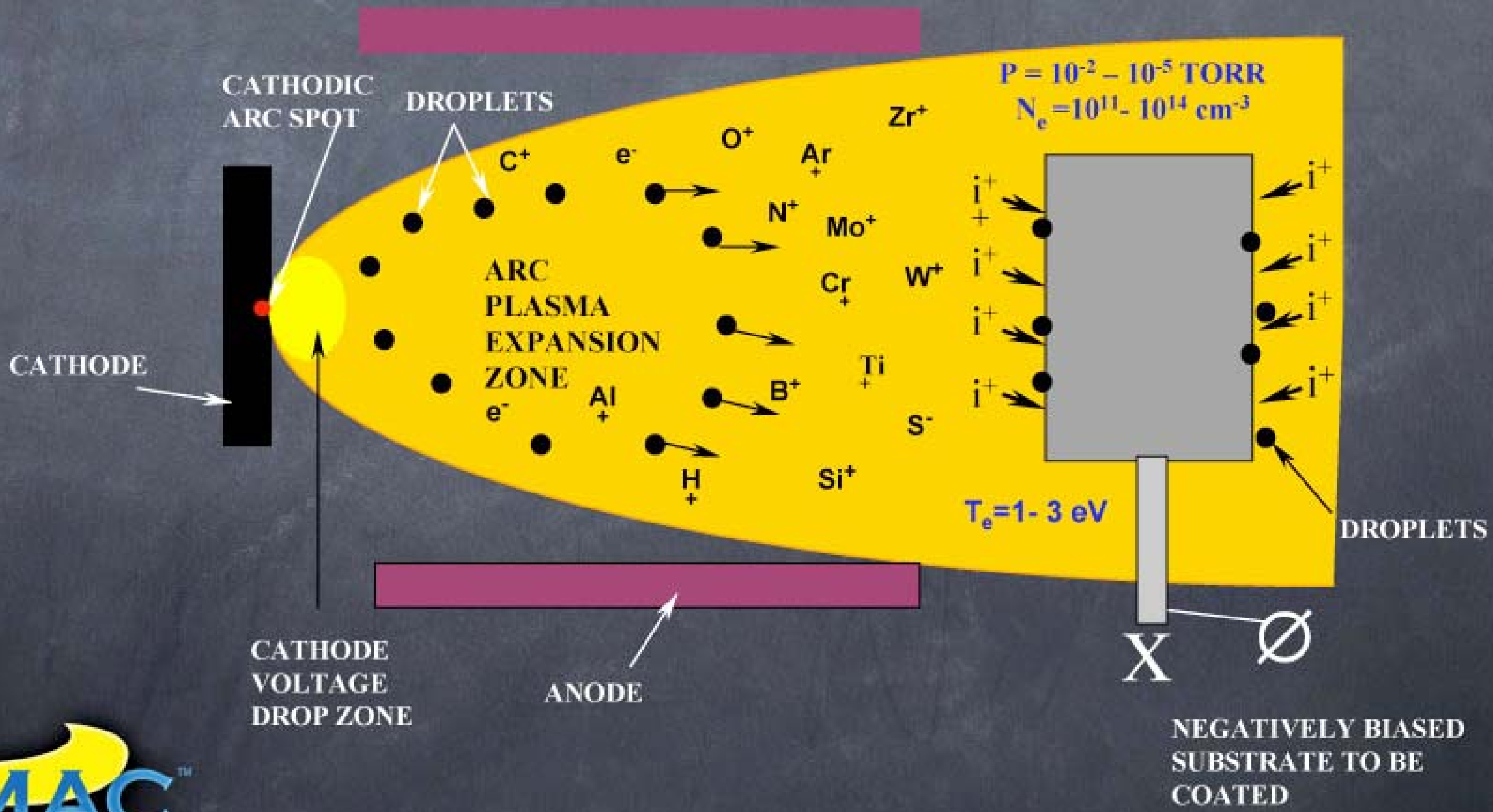
Split field magnetic steering design: close field arch along short side of the target; open field arch along long side of the target

Ti target



Graphite target

Cathodic Arc Plasma Immersion Technology Diagram



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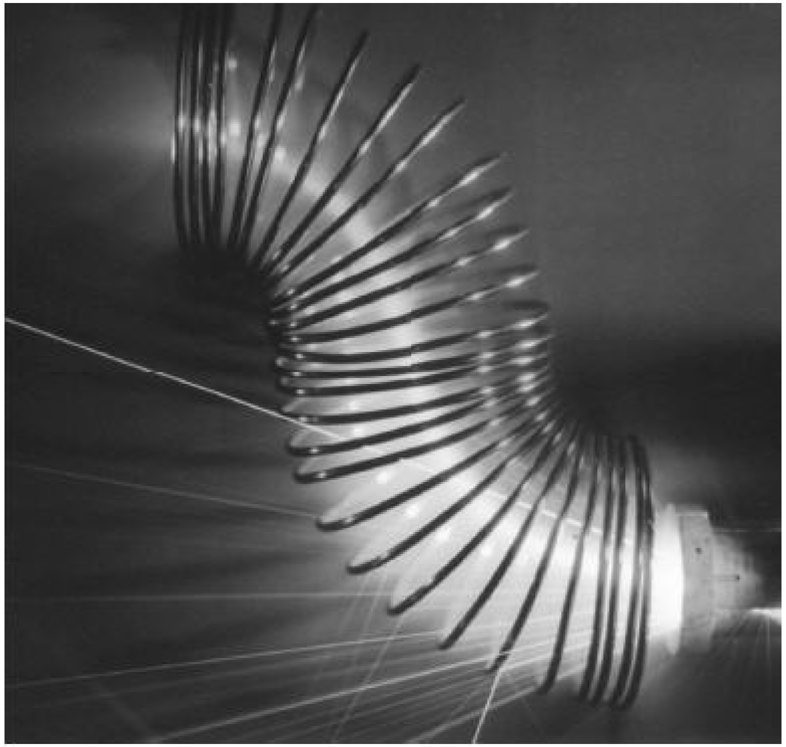
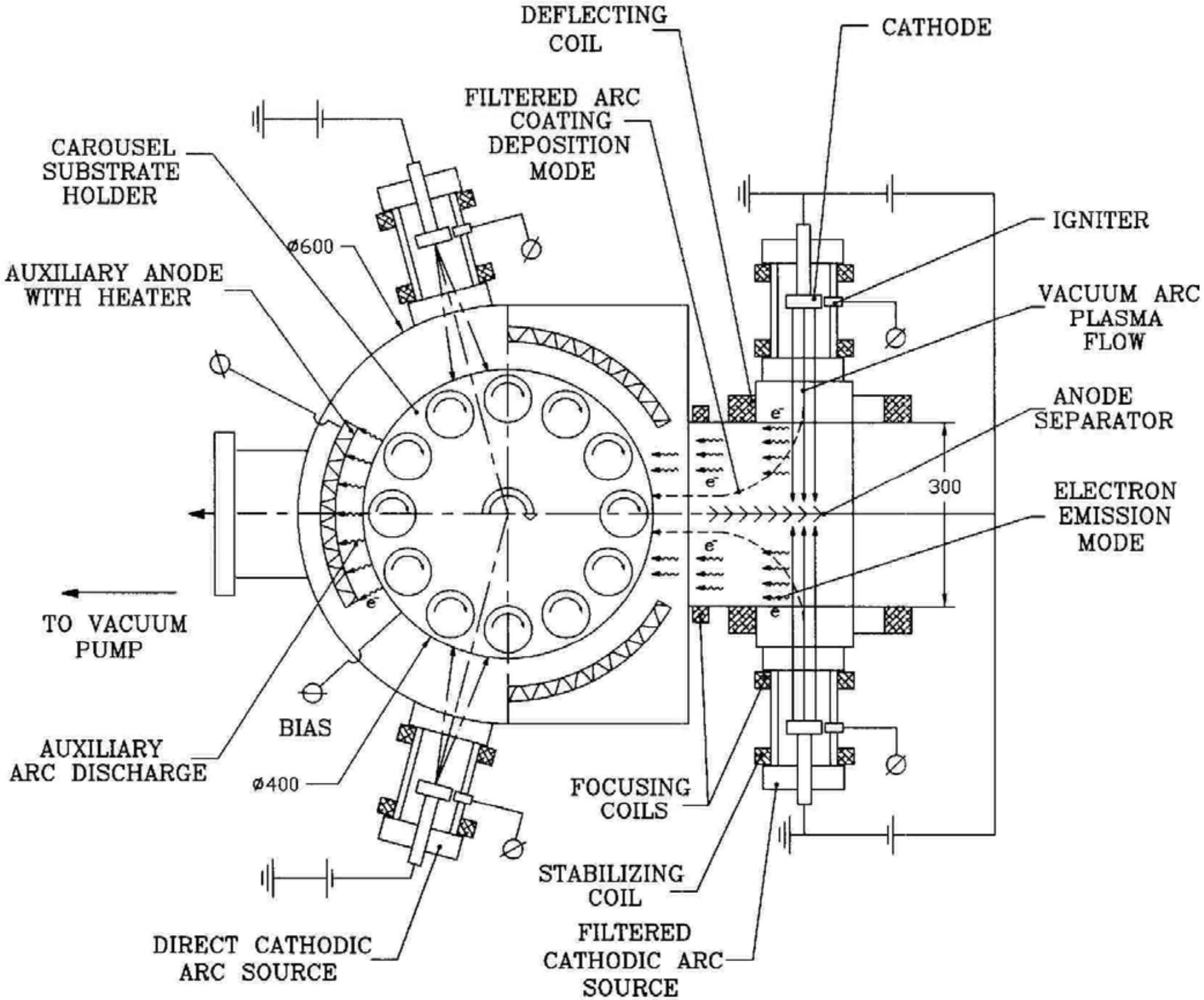
Conventional FAD plasma sources with arc plasma confined in a magnetic field created by tubular solenoids of different configurations: scale-up limitation



S-shape tubular solenoid- plasma duct
Courtesy of A.Anders et al.

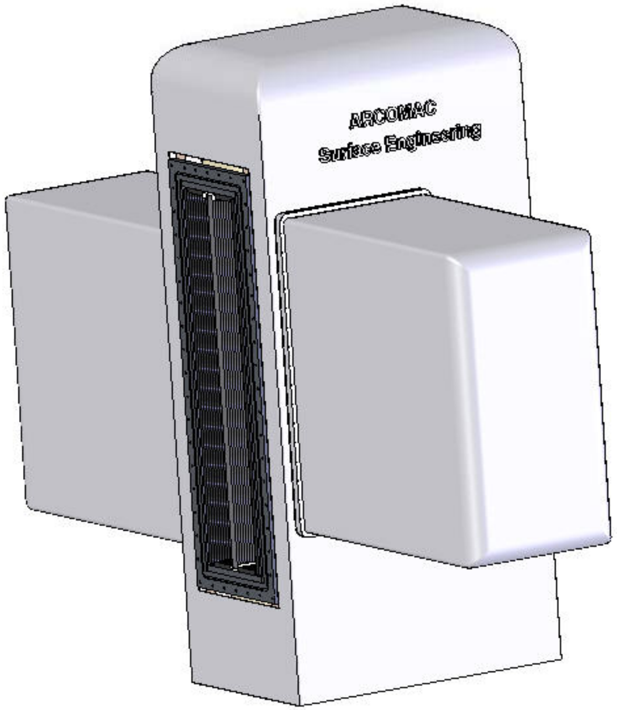
Quarter-torus tubular solenoid- plasma duct

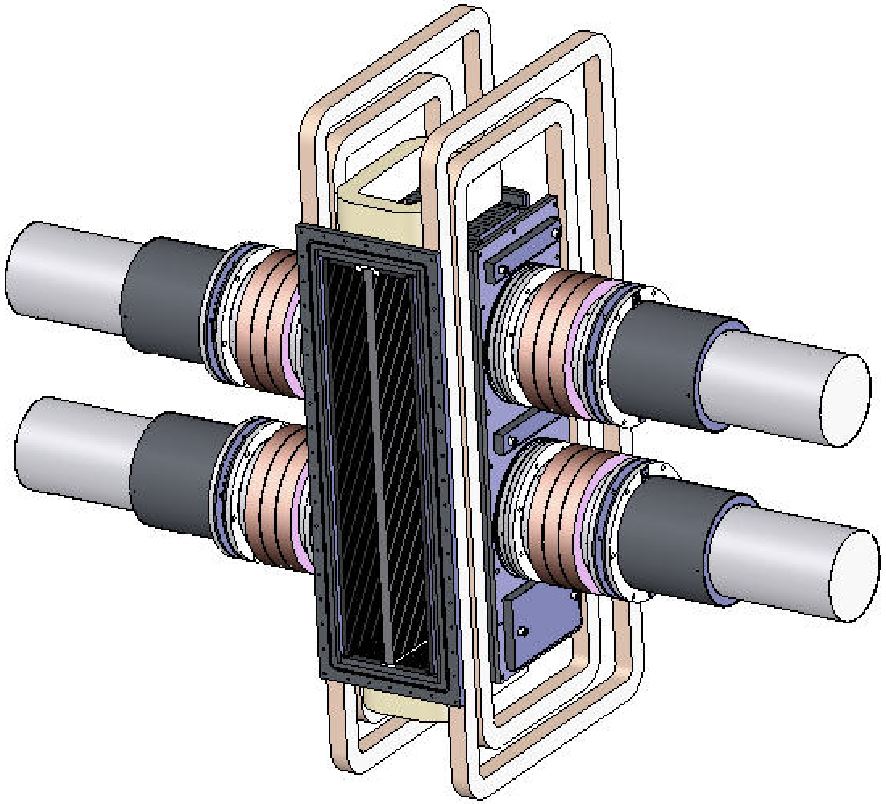
ARCOMAC's coater with LAFAD™ and Direct CAD sources

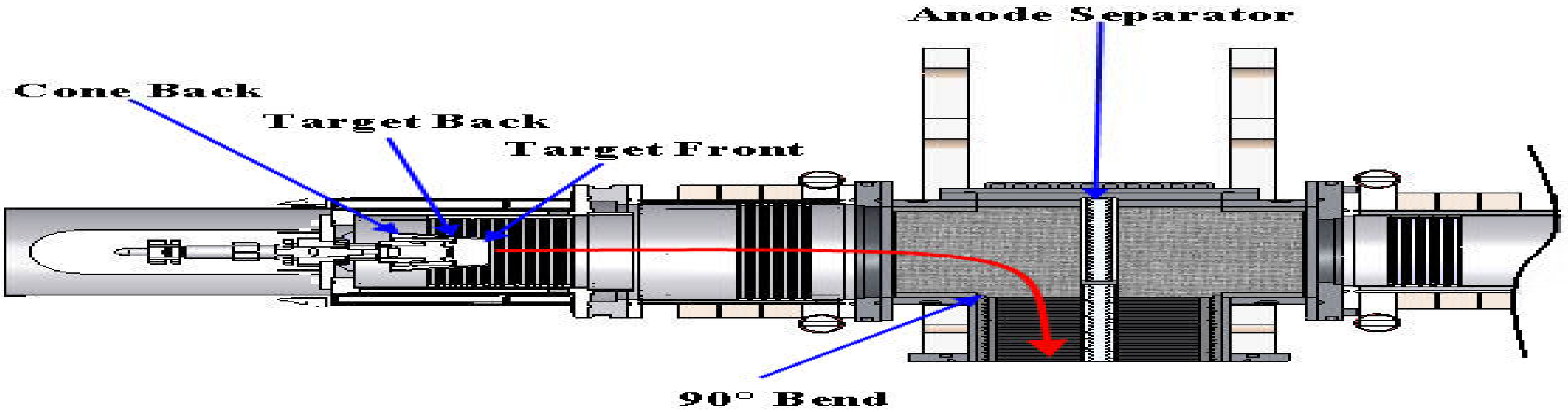


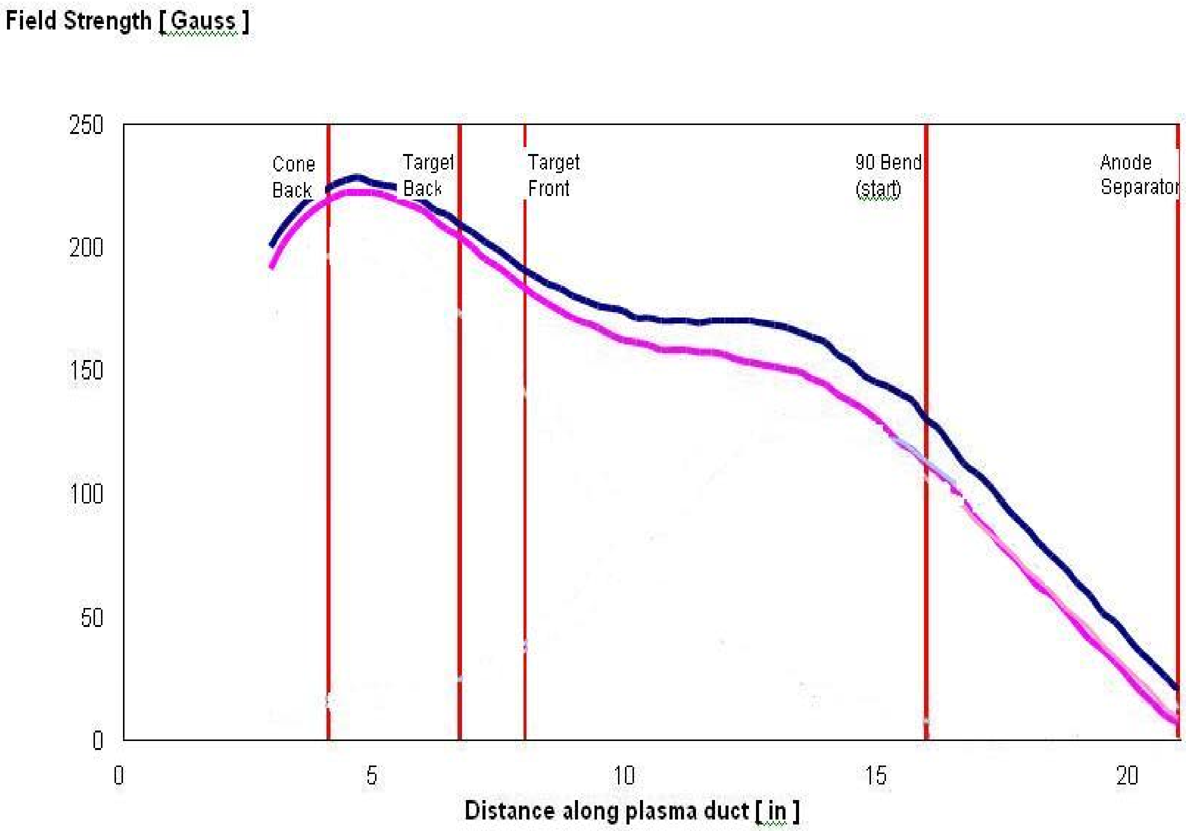
ARCOMAC's coater layouts with one LAFAD^{TM} source and two direct cathodic arc deposition DCAD-300C plasma sources: this system is currently in operation at UES, Inc., Exactatherm, Ltd. and American Eagle Instruments, Inc.

LAFAD™-1000-C unidirectional dual filtered arc plasma source: modular scalability approach



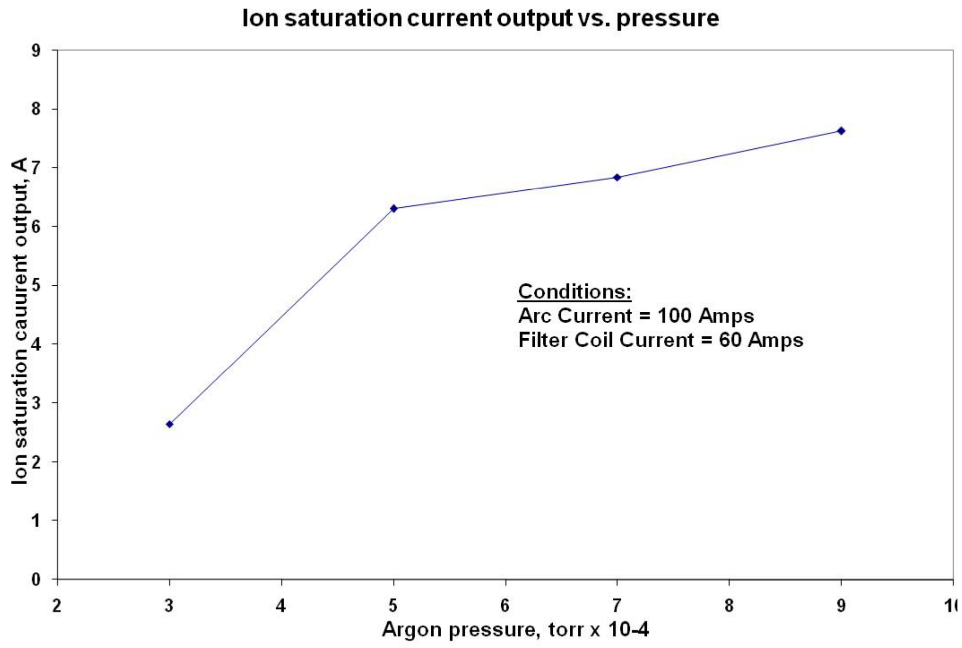


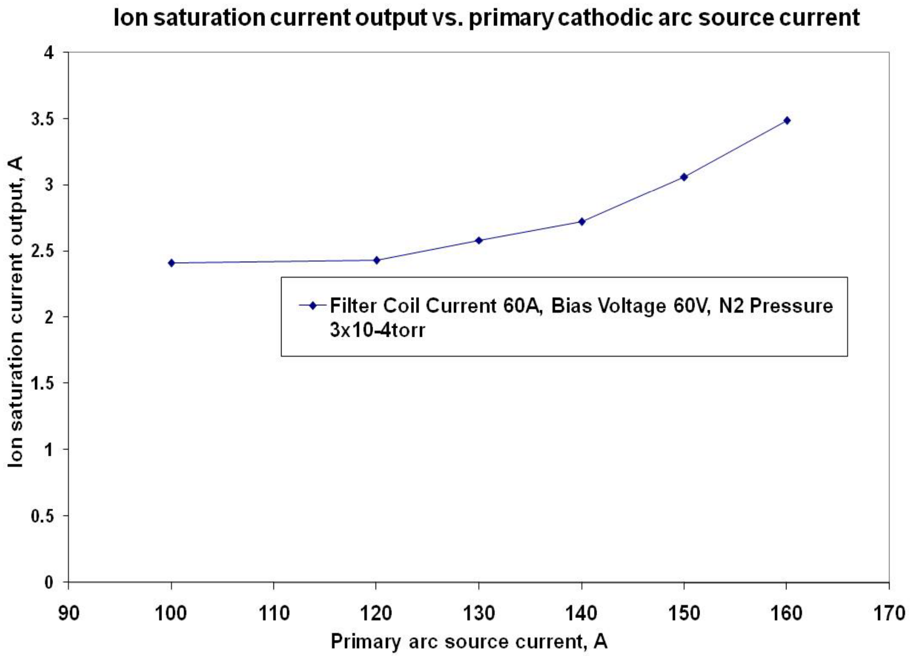




Distribution of axial magnetic field along the plasma passage in LAFAD™ unidirectional dual filtered arc source

LAFAD™ Ion Saturation Current Output vs. Process Parameters





Performance of the LAFAD^{TM}-500 unidirectional dual filtered arc plasma source with rectangular vs. circular primary direct cathodic arc deposition (DCAD) plasma sources

LAFAD^{TM}-500C with circular primary DCAD sources

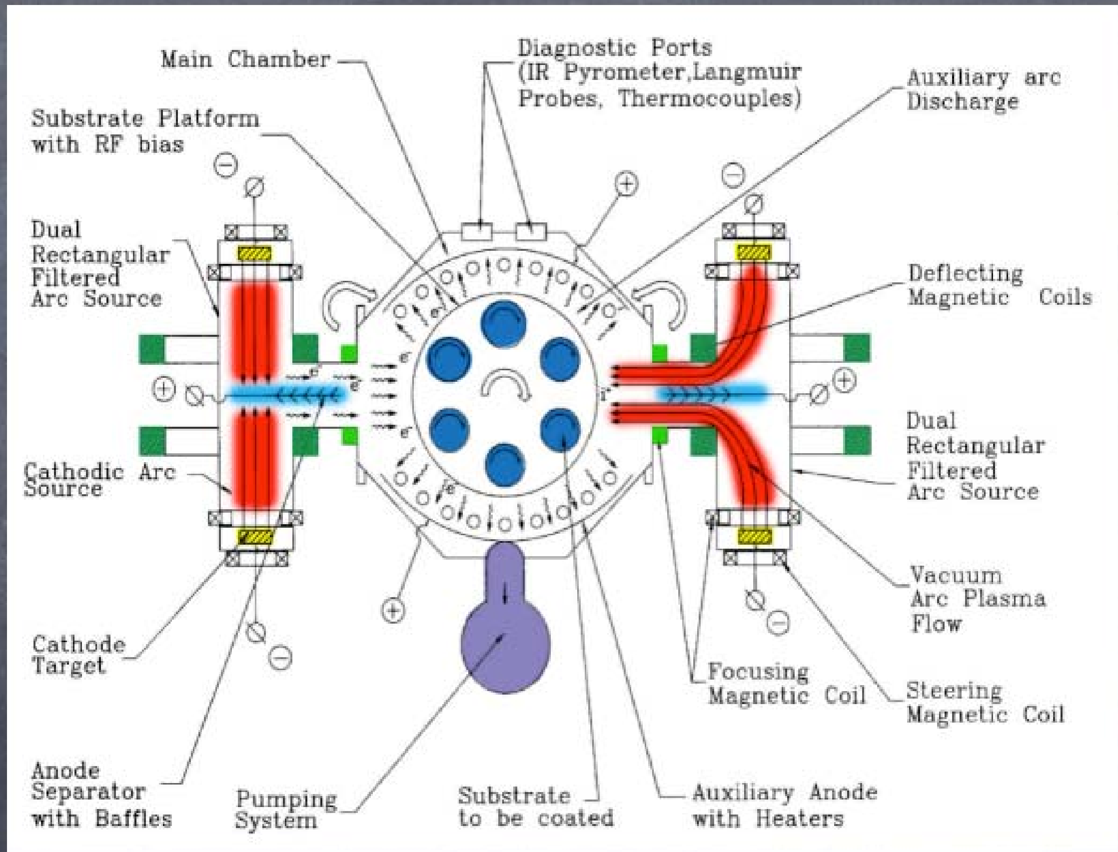
LAFAD^{TM}-500R with rectangular primary DCAD sources

Large Area Filtered Arc Deposition
LAFAD

In Situ Process & Equipment Drawing featuring multiple cathodes, multiple material element combination

- Cathode Arc Sources
- Deflecting Magnetic Coils
- Steering Magnetic Coil
- Plasma Stream
- Anode Separator (Filter)
- Substrate Holders
- Vacuum Pump

In Situ Plasma Stream



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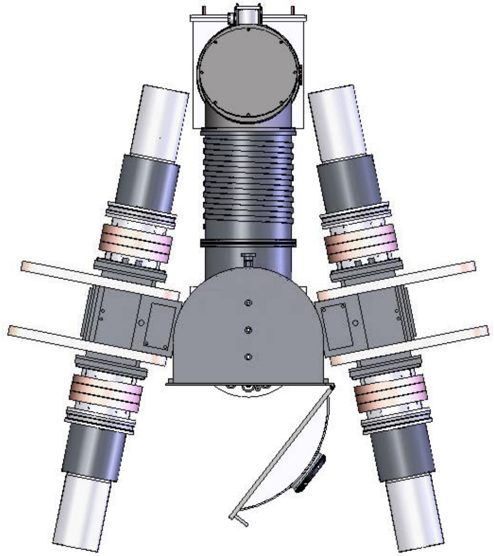
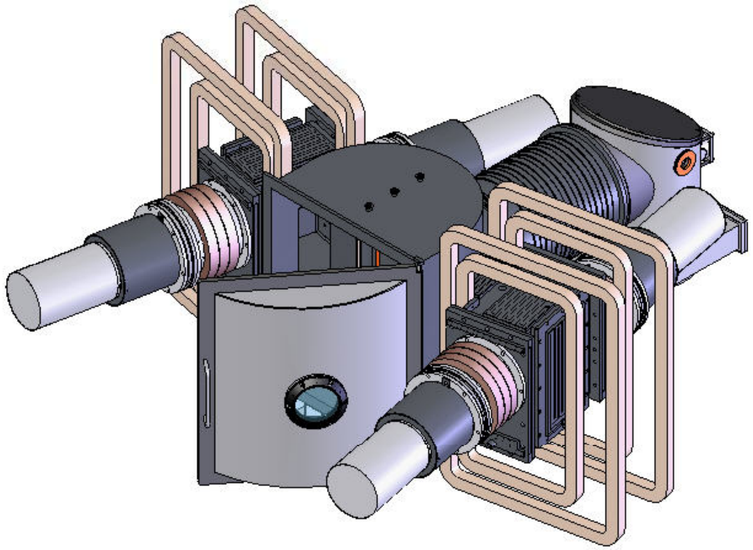
ARCOMAC's coater layouts with two LAFAD^TM plasma sources

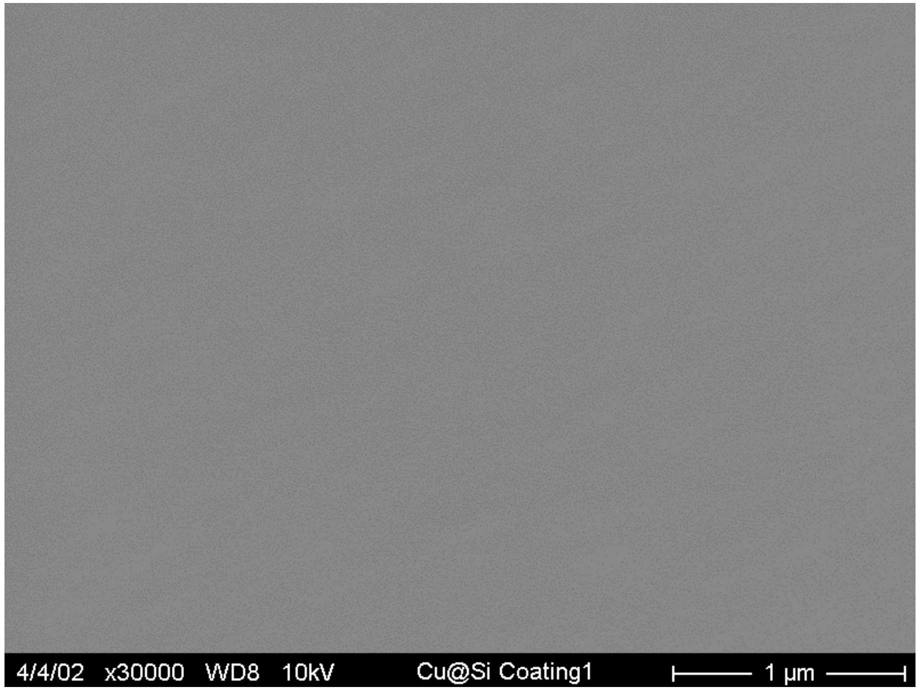




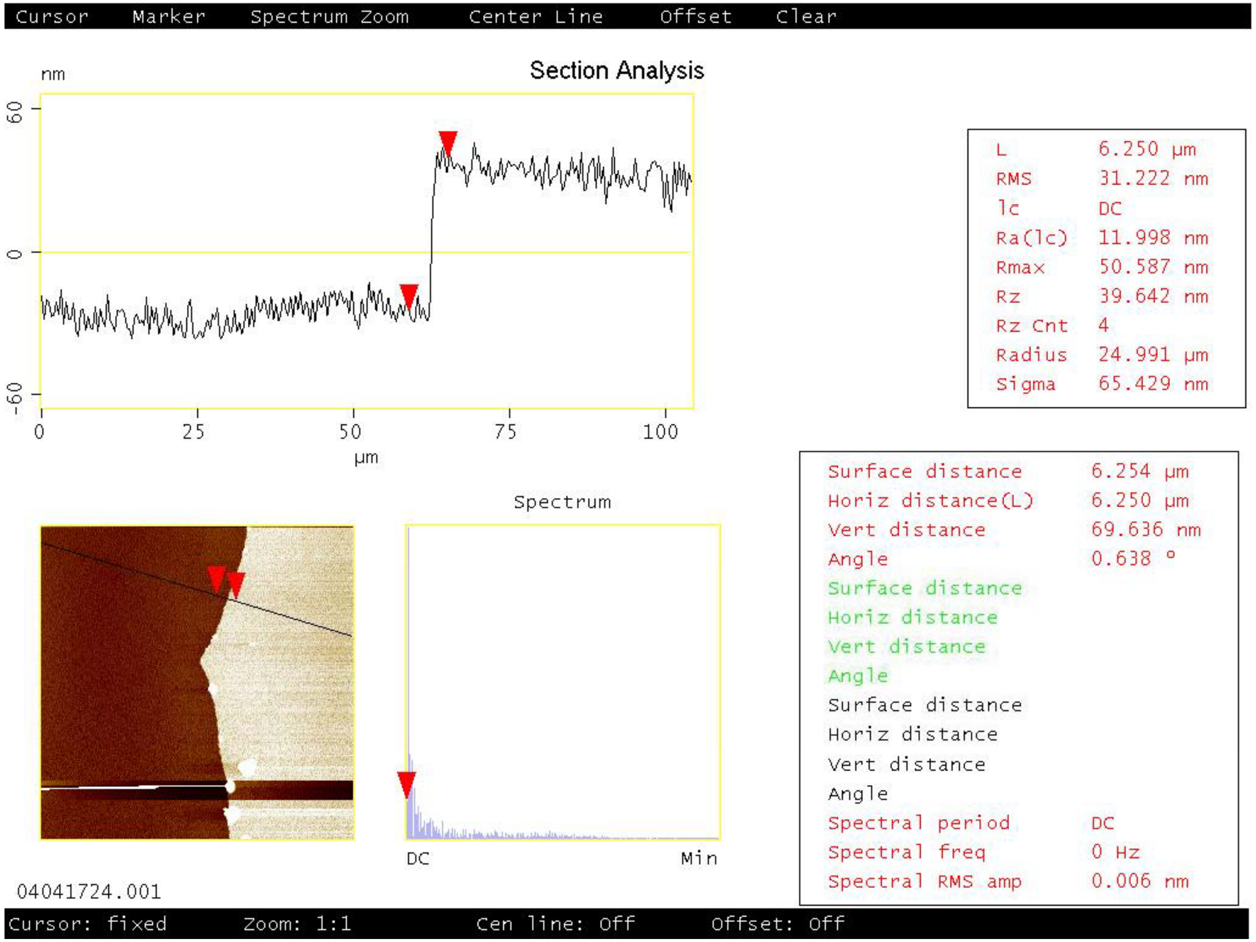
Arcomac Large Area Filtered Arc Deposition (LAFAD™) Technology Highlights:

- **Atomic-level (atom-by-atom) deposition**
- **No target poisoning and no need in sputtering gases (Ar)**
- **Can operate without residual gas atmosphere, such as for deposition of hydrogen free DLC from carbon plasma**
- **Nanostructure size ceramic crystal growth at the nanometer level**
- **Capability of producing super-lattice and nanocomposite structuring with multi-phase ultra-fine polycrystalline and/or amorphous structures**
- **Super adhesion properties**
- **High ionization and activation of metal-gaseous plasma (up to 100% for metal vapor and more than 50% for gaseous plasma)**
- **Capable of supporting the duplex and triplex plasma immersion surface engineering processes in one vacuum cycle**
- **Capable of supporting near all PVD and low pressure CVD processes in strongly ionized filtered arc plasma immersion environment , which allows for "hybrid" processing and enhancement of conventional PVD and CVD processes**
- **Arcomac's modular design approach is commercially scalable and cost effective for individual customer requirements**

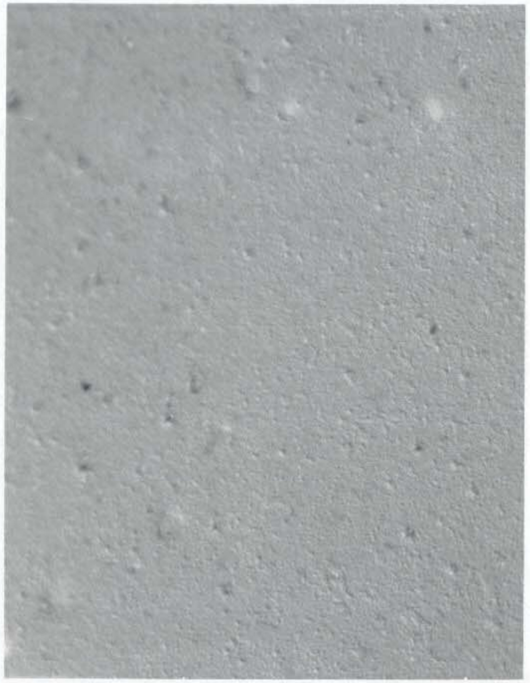
LAFAD^{TM} Copper coating on Silicon



COPPER PROFILE



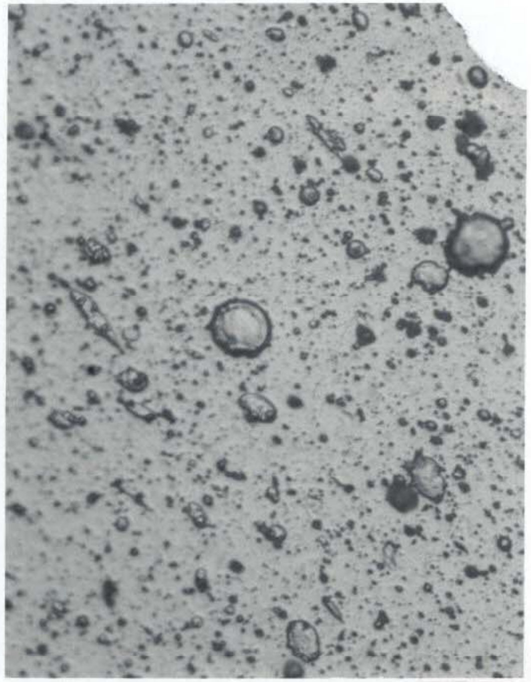
LAFAD VS. CONVENTIONAL CATHODIC ARC DEPOSITION TiN ON St.St.



X400

Filtered Arc

R_a = 0.01 μm



X400

Direct Arc

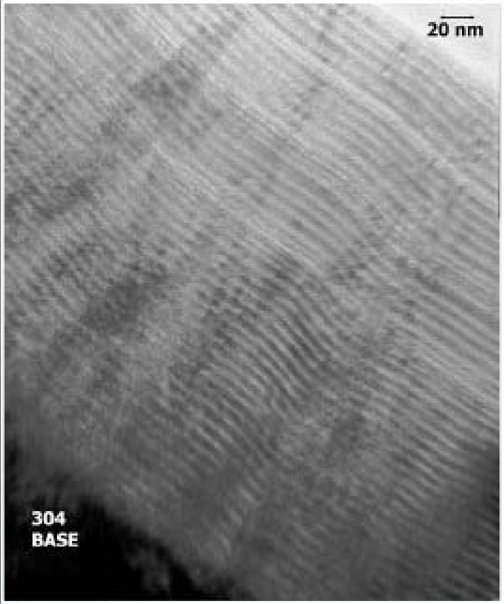
R_a = 0.4 μm

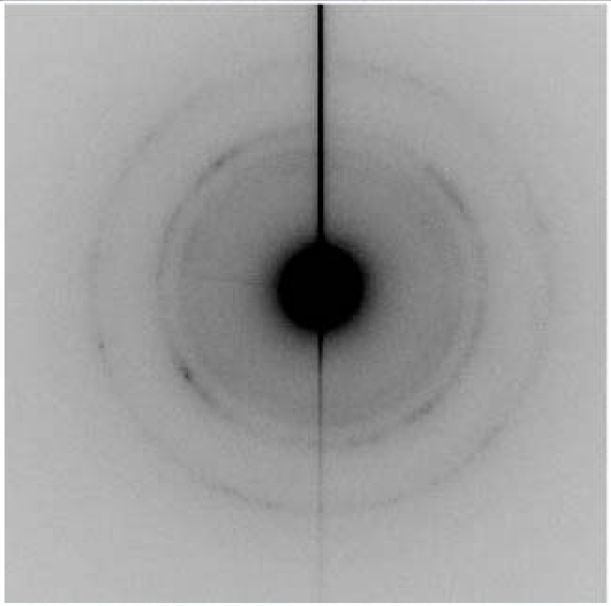
TiN

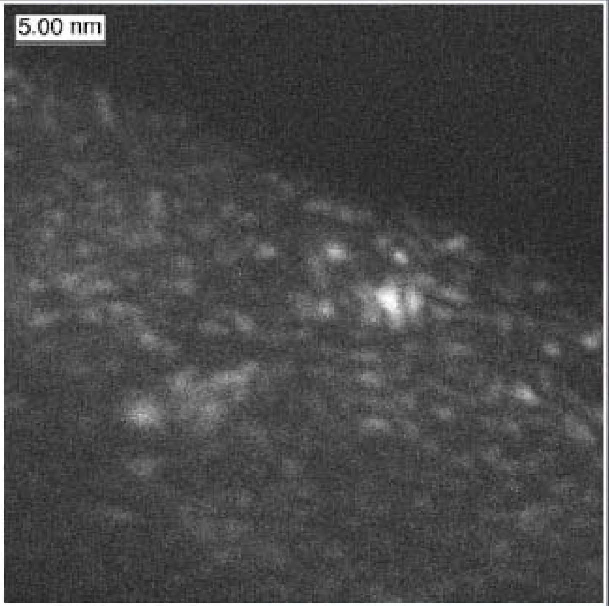
Superlattice Nanocrystalline CrN/CrAIN Coating

with size of grains 1nm

Courtesy of Dr. David Gelles, PNNL, Richland WA







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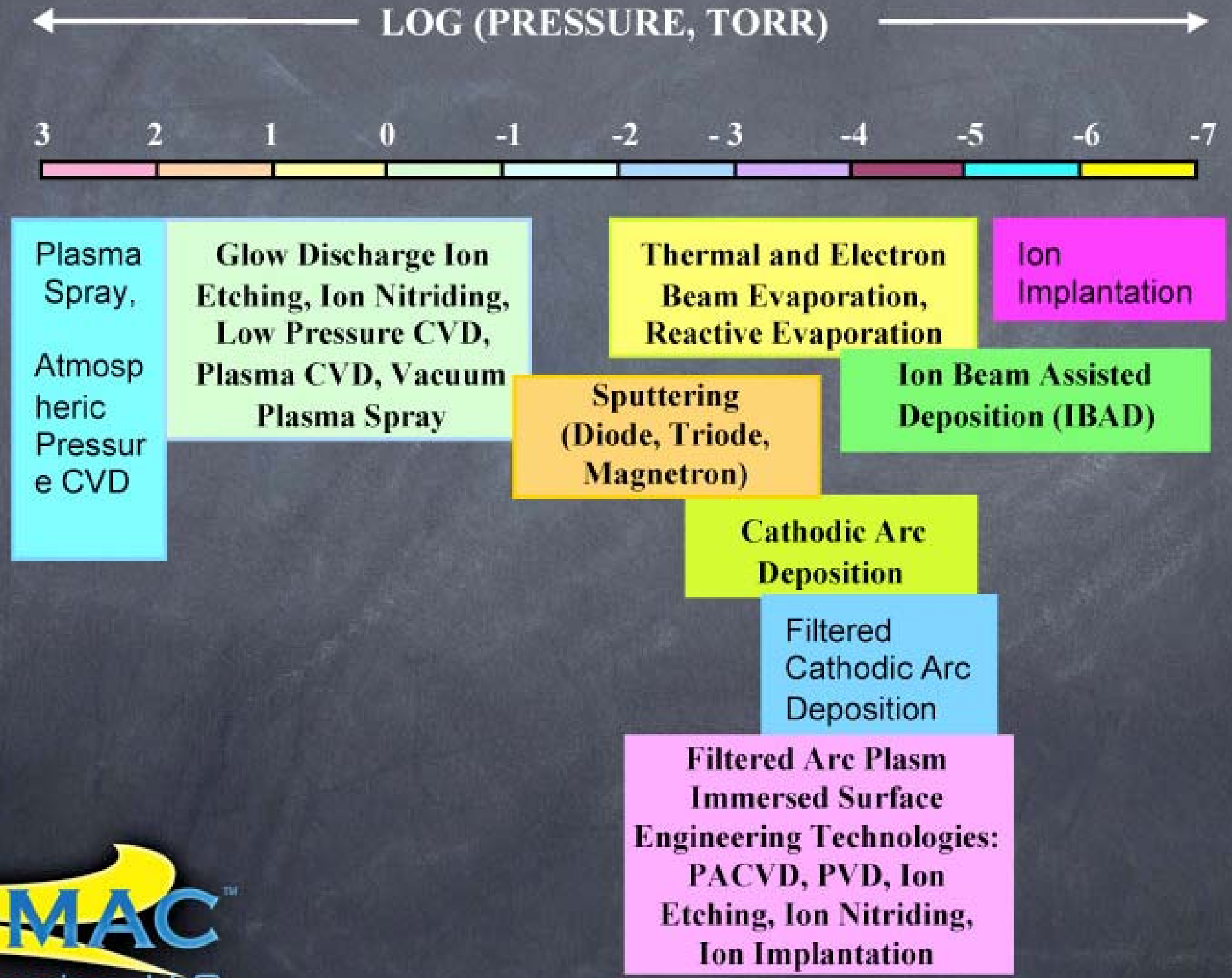
Operating Pressures for various Plasma Surface Engineering Processes



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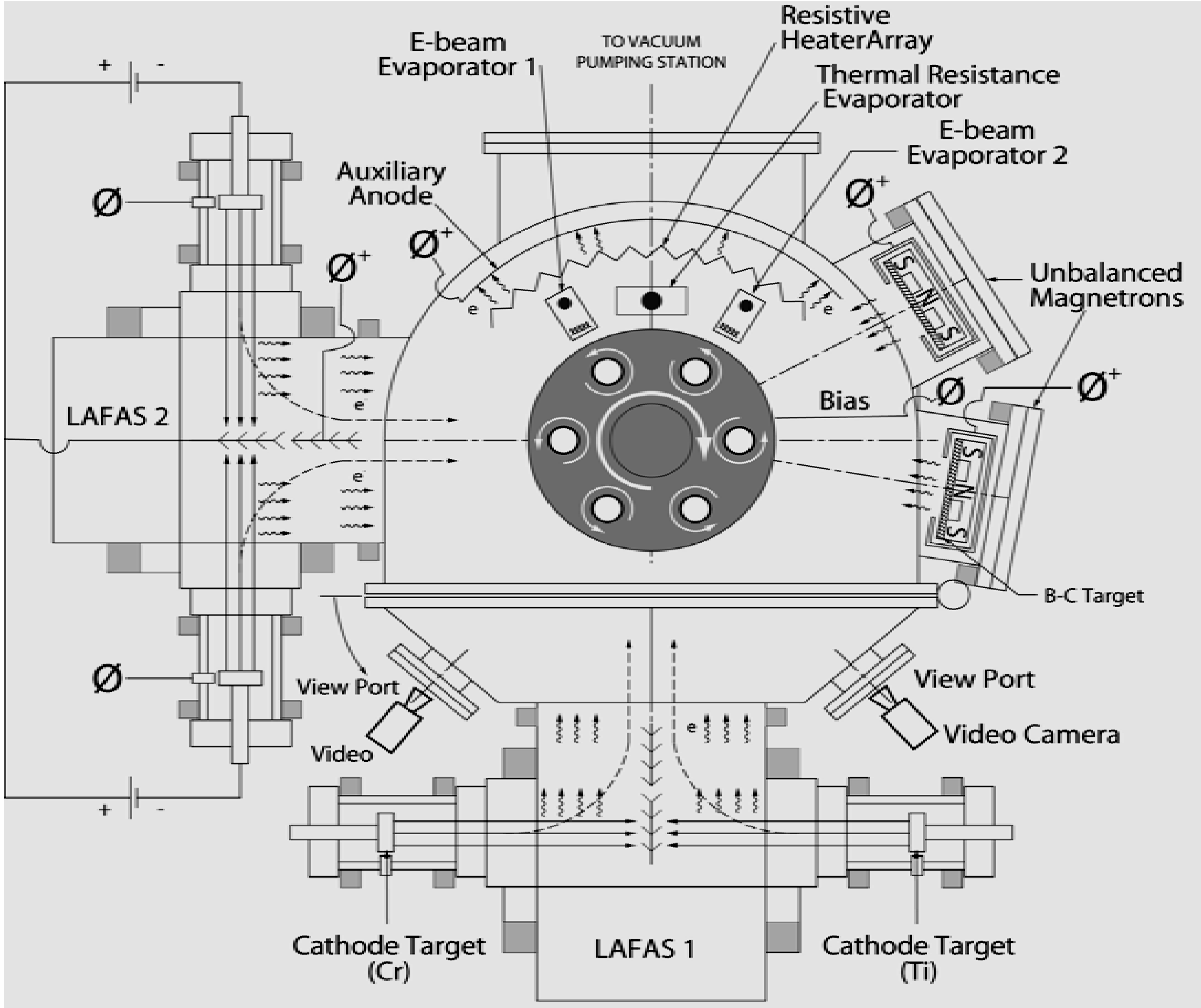
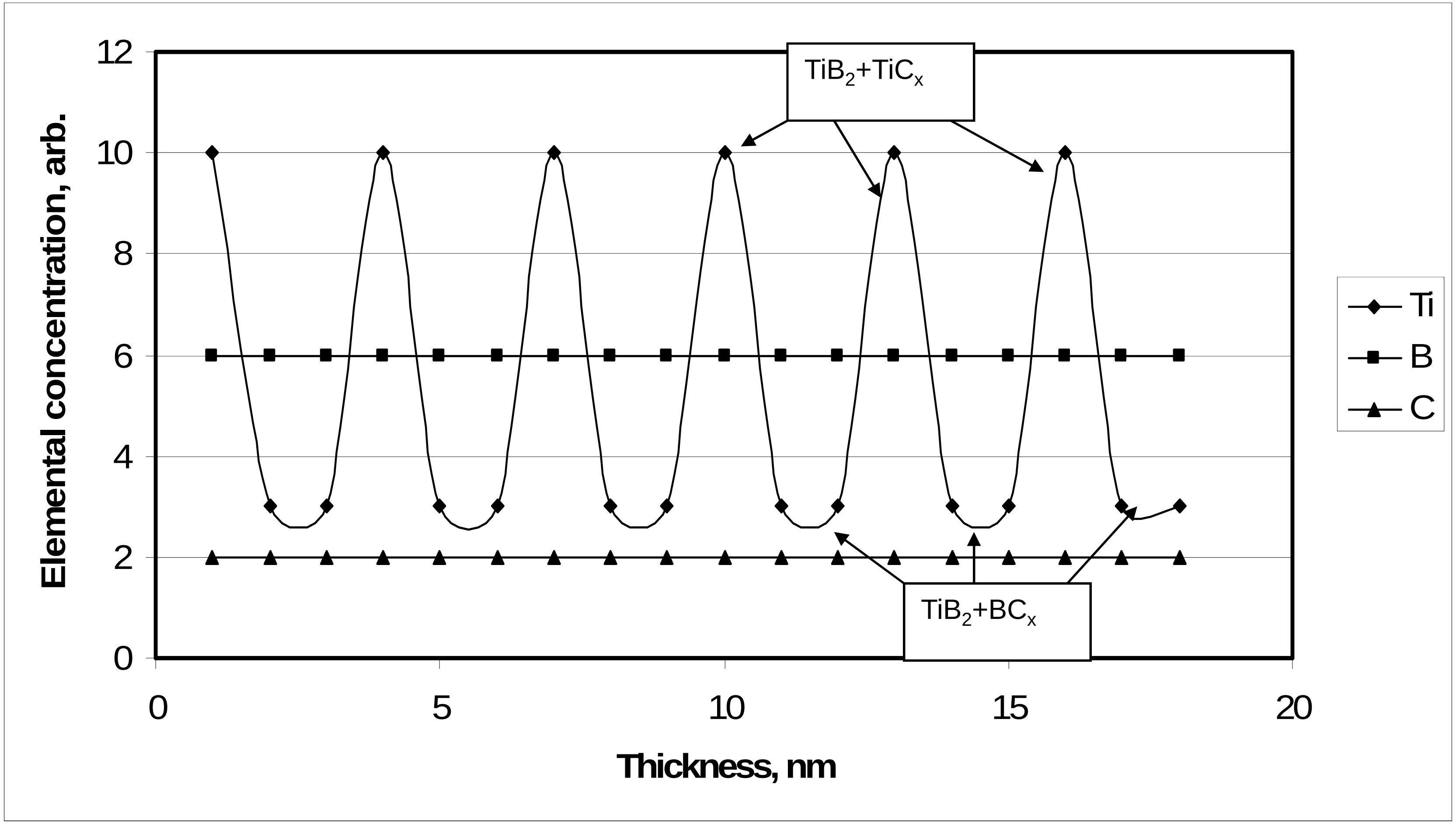
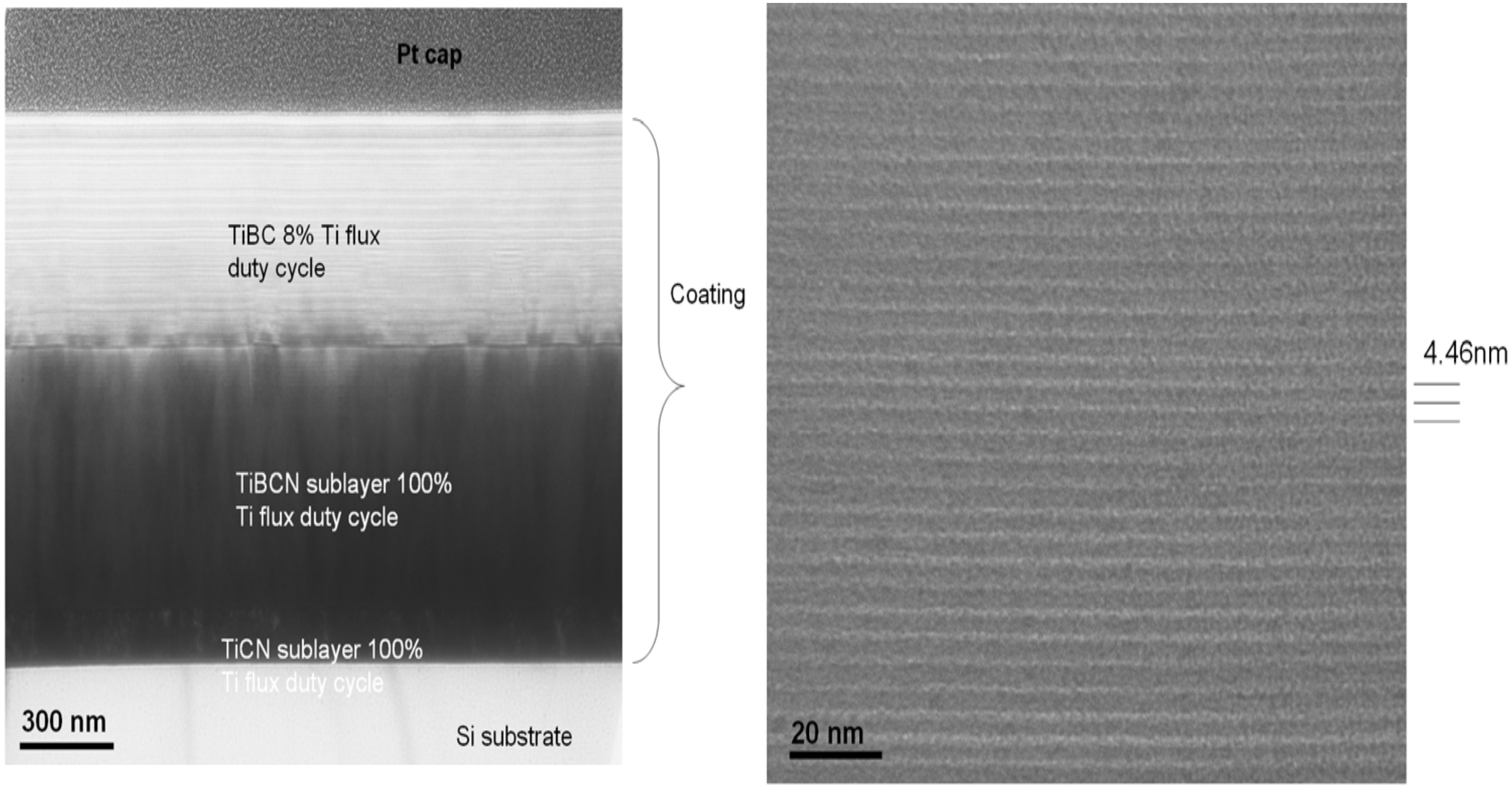
Schematic illustration of Arcomac Surface Engineering Filtered Arc Plasma Source Ion Deposition (FAPSID^{TM}) surface engineering system. This system utilizes the Large Area Filtered Arc Deposition (LAFAD^{TM}) sources in a universal hybrid layout with conventional PVD sources.



Schematic illustration of elemental distribution across TiBC FAD+UBM hybrid FAPSID™ coatings



HRTEM cross-sectional image of the TiBC nanolaminated architecture deposited by hybrid FAPSID™ process: a- complete top segment architecture; b-magnification of the top end of the TiBC segment.



Courtesy of C.Muratore

Conclusions:

• Large area filtered arc deposition (LAFAD™) process developed by Arcomac offers coating deposition and ion treatment in highly ionized plasma immersion environment

•The line of unidirectional dual arc LAFAD™ vapor plasma sources are capable of covering large coating area and can be easily integrated both into batch and in-line coating systems as additional vapor plasma source or replacement for conventional planar magnetron or direct cathodic arc source

• LAFAD™ source can deposit metals, ceramics (nitrides, carbides, oxides etc.) as well as superhard DLC and related coatings with high deposition rates

•LAFAD™ sources operating pressure range overlaps most of low pressure conventional PVD and CVD processes, which make it possible combining LAFAD™ sources with conventional PVD sources (EBPVD, magnetrons, thermal evaporators) and CVD sources in hybrid surface engineering systems layouts

•The LAFAD™ filtered vapor plasma flows can be manipulated with magnetic fields providing excellent uniformity of coatings over large area complex shape substrates. This results in deposition of nano-structured coatings with unique nanocomposite and modulated architectures.

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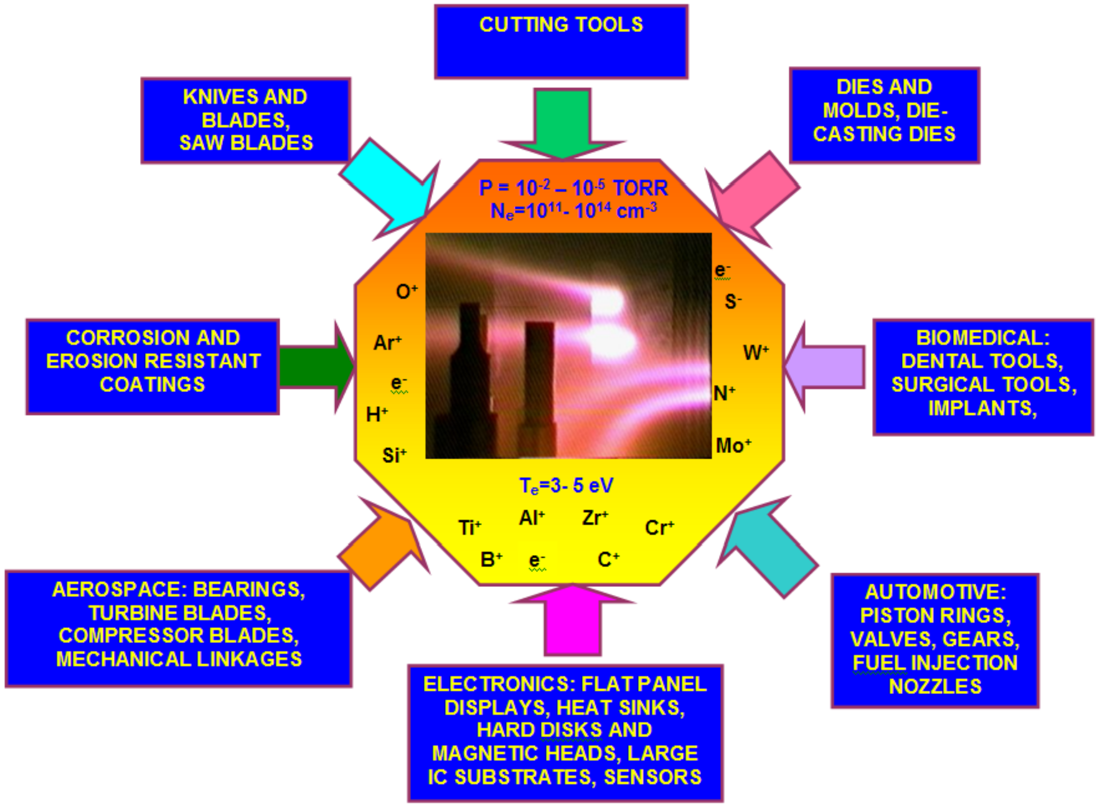
Providing Advanced Surface Engineering Solutions for Demanding Applications:



Arcomac has developed and now offers the line of models of unidirectional dual Large Area Filtered Arc Deposition (LAFAD™) sources for retrofit or integration into conventional coating equipment. These sources are covering deposition areas ranging from 0.5 m up to 2m and more.

Please visit our booth No.38 for more information regarding Arcomac technologies, applications and the updated LAFAD™ product line.