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Overview of Electron Emitter Technology Development at TU Dresden for the Application in Electrodynamic Tether Systems

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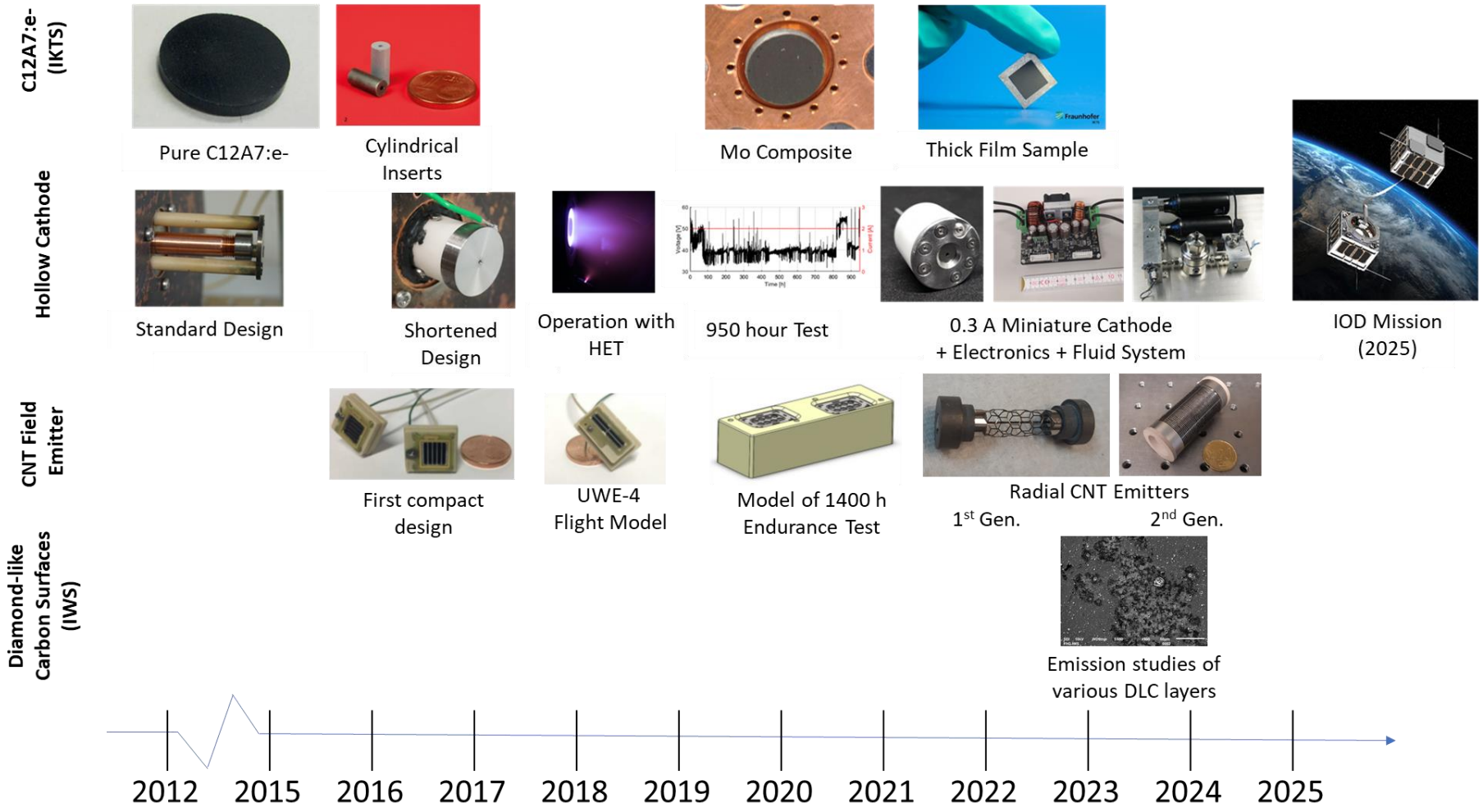
Agenda

- Timeline of ~10 Years of Electron Emitter Development at TU Dresden
- Three Electron Emitter Technologies:
  - Compact Heaterless Cathode
  - Radial CNT Field Emitter

  } Full emitter designs

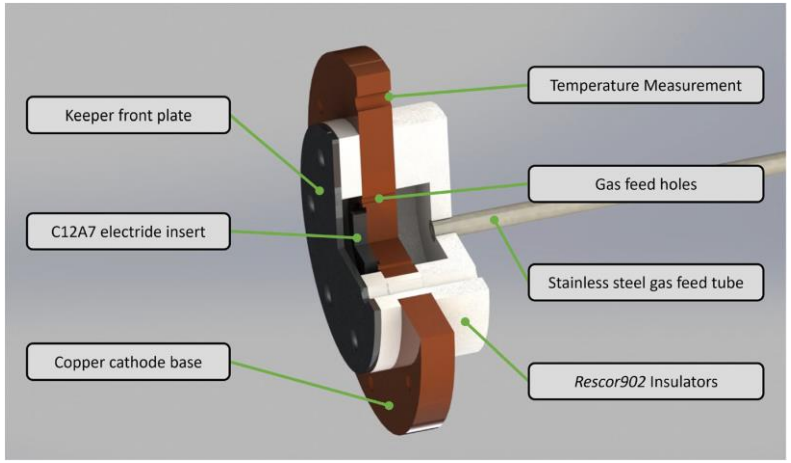
  - Diamond-like Carbon (DLC) Emission Surfaces → Material Analysis

Development Timeline

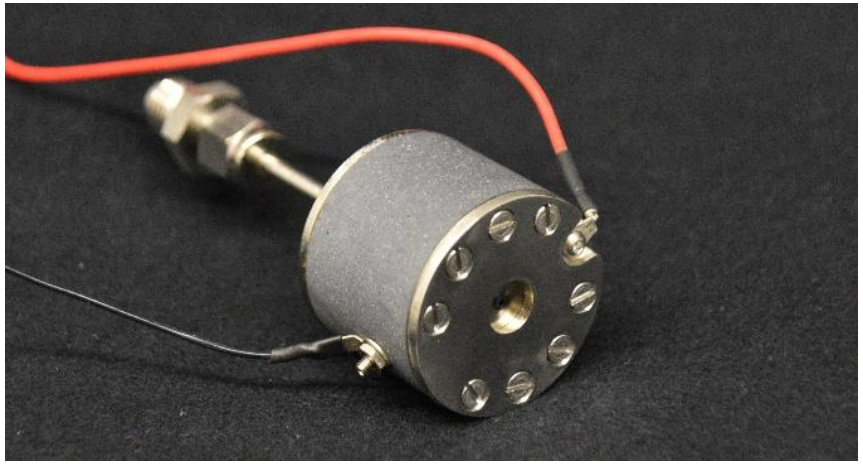


Compact Heaterless Hollow Cathode

- Hollow Cathode based on C12A7 electride (C12A7:e-) emitter
- Low work function allows heaterless ignition by high voltage pulse
- Optimized for nano and microsats



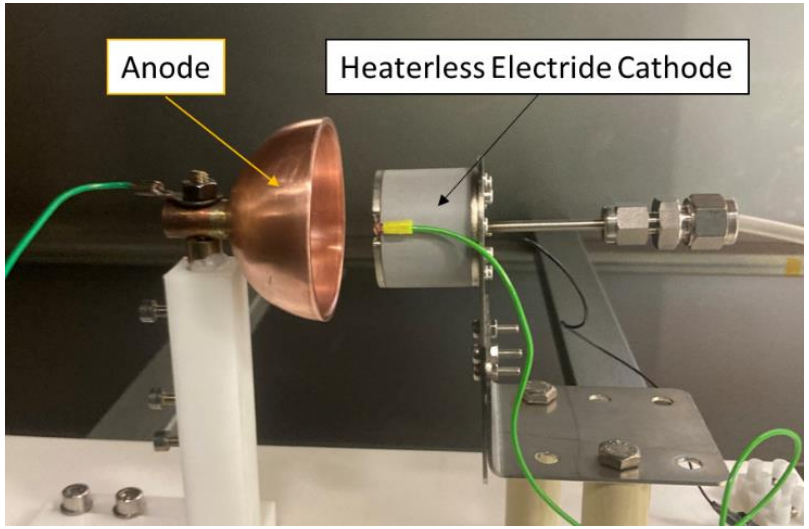
Breadboard model (cross-section view)

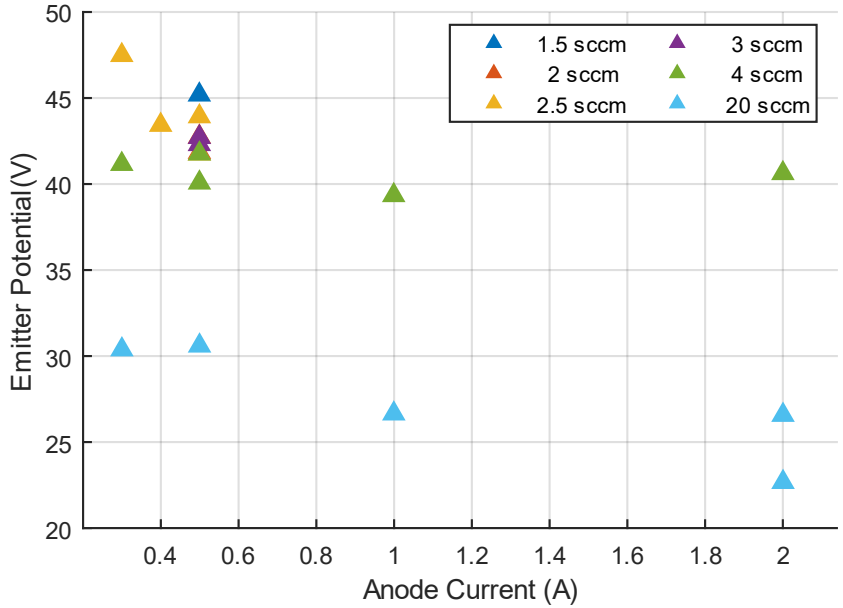

Engineering model

Compact Heaterless Hollow Cathode

- Hollow Cathode based on planar C12A7:e- emitter
  → performance achieved through joint development with Fraunhofer IKTS
- Emission tests in triode configuration

Property	Value
Discharge current range	0.3 – 2 A
Discharge potential	< 30 V (20 sccm Kr, 2 A) < 45 V (4 sccm Kr)
Low Power Consumption	< 25 W (0.3 A, 4 sccm)
Low mass flow rate	< 4 sccm (Kr)
Total operational time	950 h
Ignition Cycles	500

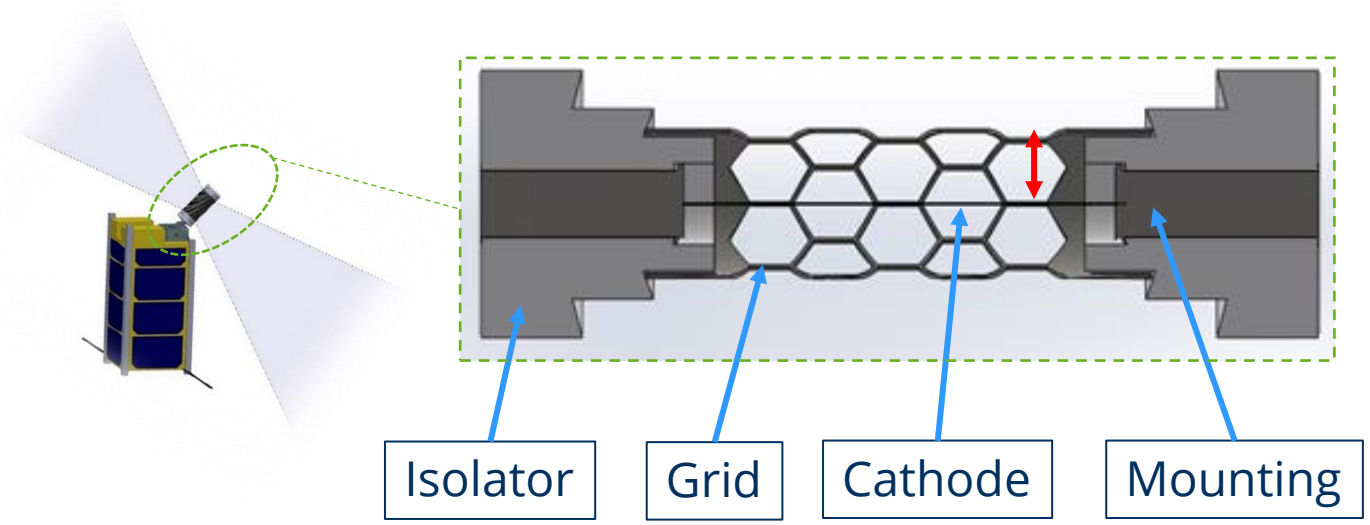


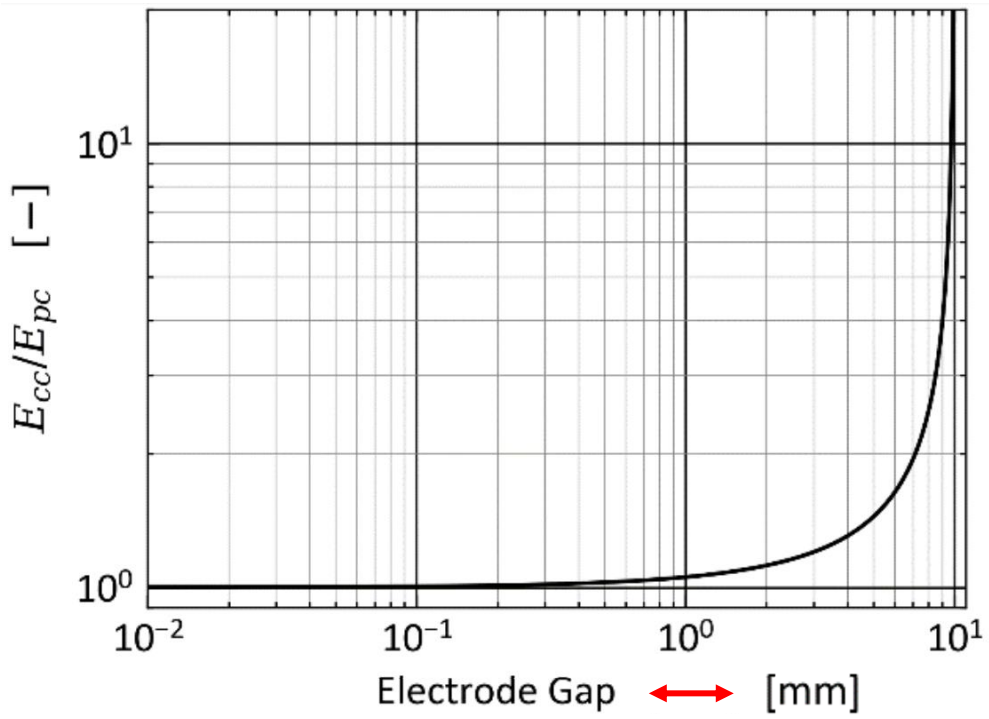


The Radial Field Emission Array Concept

- Novel design approach
- Additional field enhancement for large gaps
  (but lower emission area)

➢ Optimal configuration for EDT operation

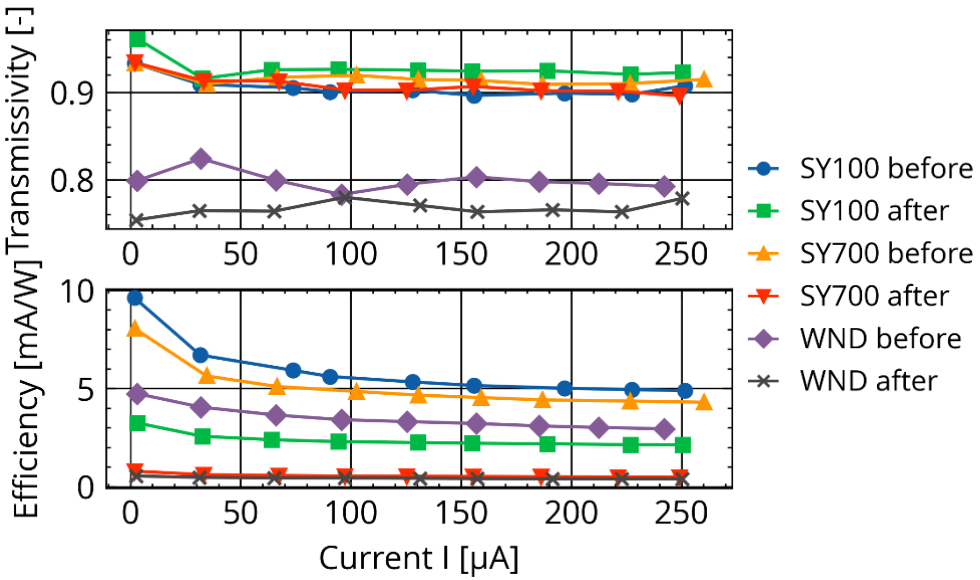




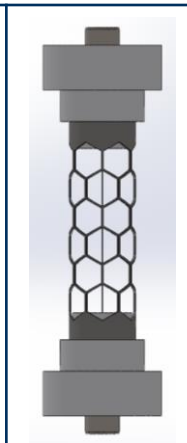
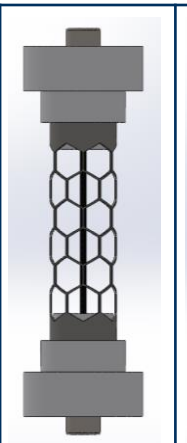
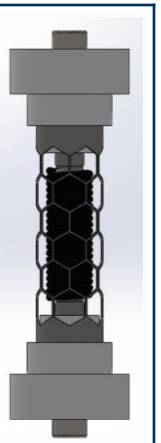
Field enhancement factor of a 20 mm diameter cylindrical condenser compared to a planar one

1st Gen. Radial CNT Cathodes Prototypes

- Freely mounted and wound CNT yarns
- Three different electrode configurations
- Large gap best, but high risk of failure
  - ➢ Large area cathodes more feasible

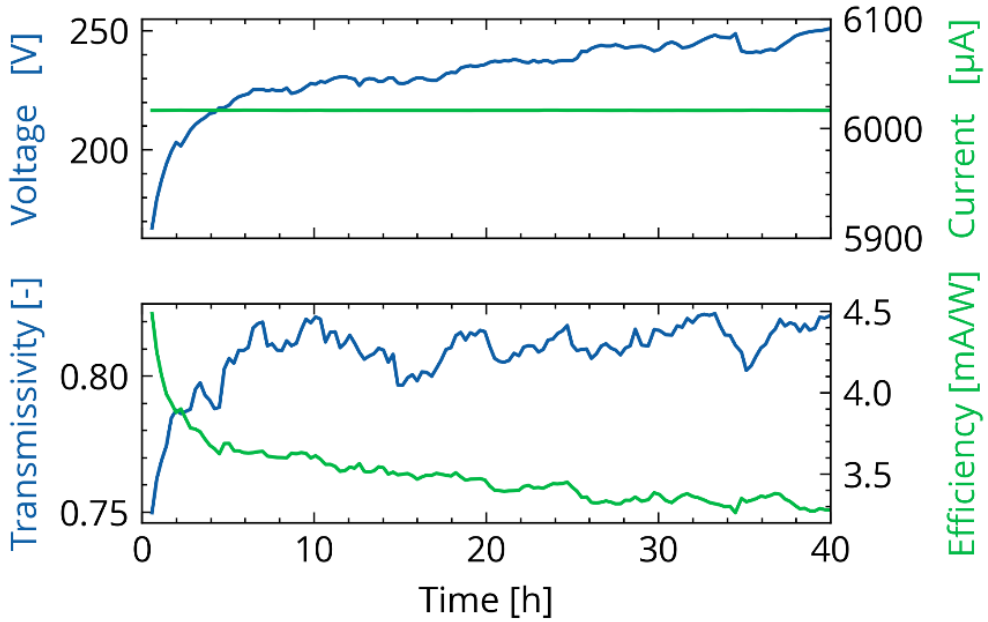


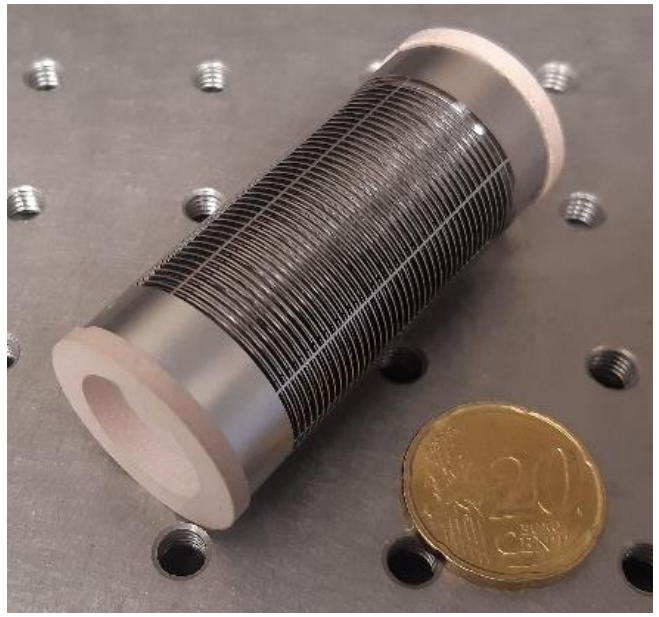
Performances before and after 300 h tests at varying currents.

CAD			
			
Configuration	SY100	SY700	WND
A_{em} [mm²]	5.7	39.6	251.9
Gap [mm]	3.25	2.95	1.13
Max. Current [mA]	1.5	3	6

2nd Gen. Upscaled Radial CNT Cathodes

- Upscaled large area, small gap configuration built
- Very high efficiencies, medium transmission rates
- Tested up to 30 mA, 100 mA expected





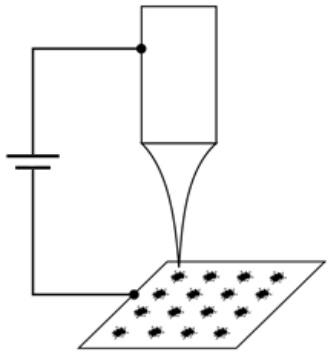
Yarn Ø [µm]	200
Pitch h [mm]	1.0
Windings	40
A_{em} [cm²]	9.5
Gap [µm]	345

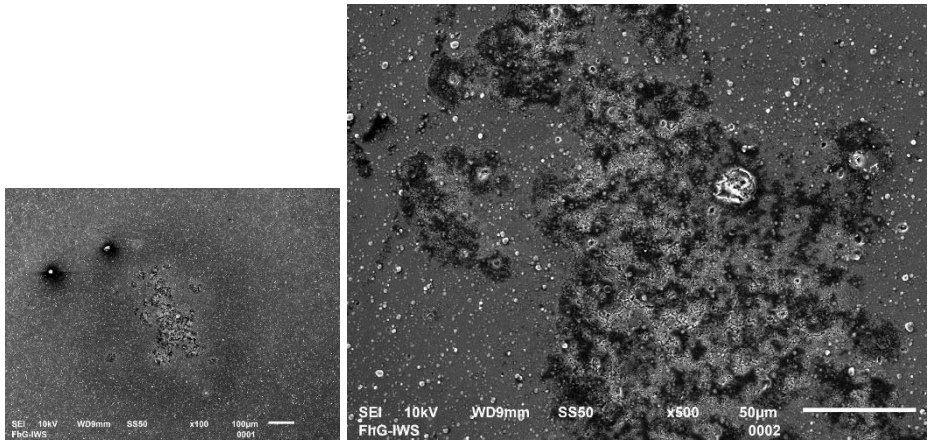
Diamond Like Carbon (DLC) Cathode Materials

- Layer activation at higher voltage necessary
- Best performance with:
  - High ta-C content
  - High electrical resistance

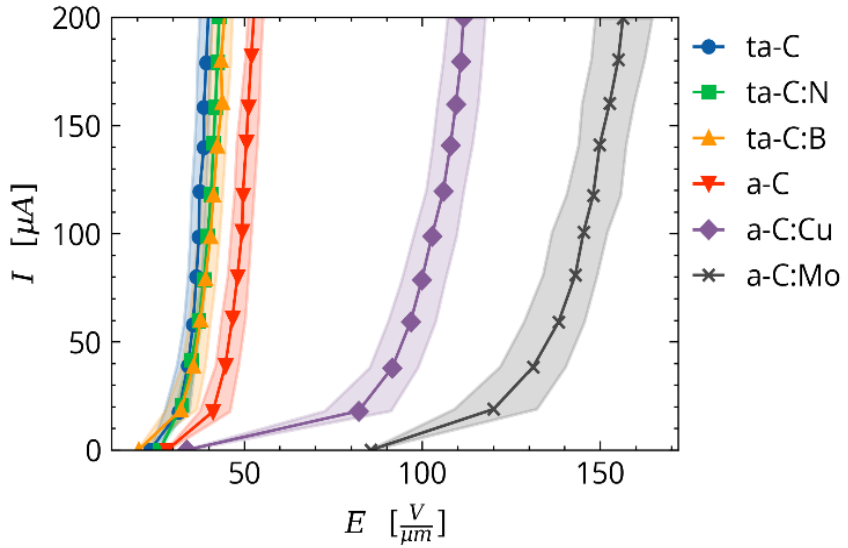
➢ Large area arrays possible

- Raster activation by field emission needle

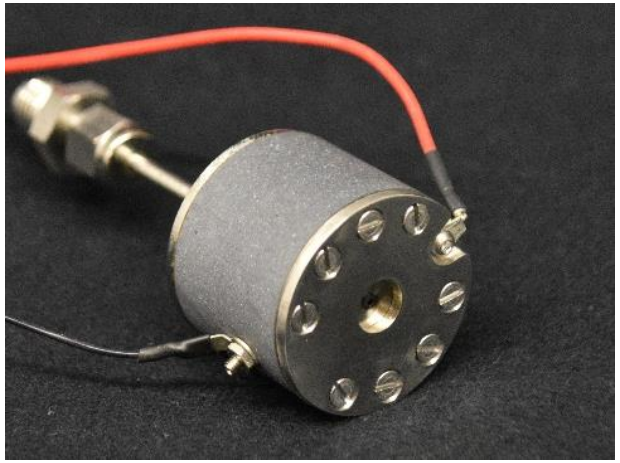


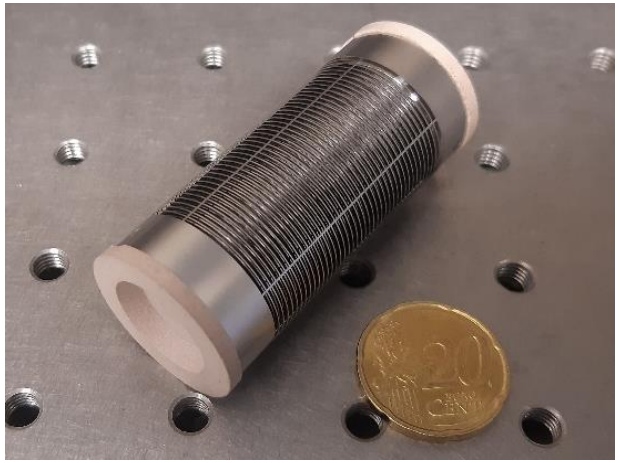


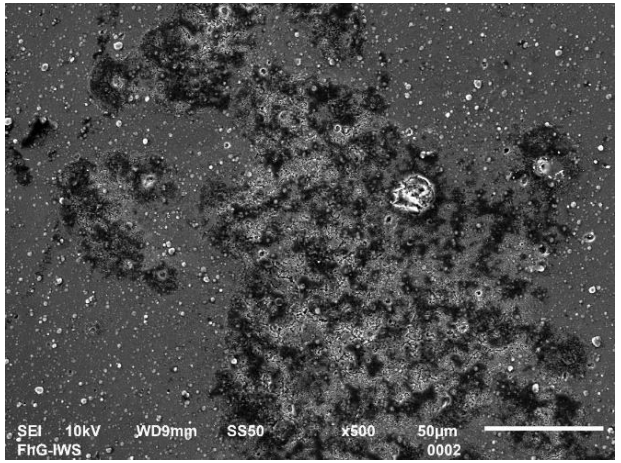
Emission spot of the ta-C sample



Summary and Outlook







Main Facts:

- 0.3 to 2 A
- C12A7:e- emitter
- Heaterless ignition

- 10 to 30 mA
- CNT Emitter

- Up to 200 mA/cm²
- DLC emitter
- Activation necessary

Next Steps:

- IOD: Q3/4 2025

- Increase current
- ATOX resistance tests

- Build arrays
- Lifetime tests

Thank you very much for your attention!

Dresden, Skyline