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Nexray RTD 2009

FNSNF

Towards miniature carbon-nanotube based X-ray sources

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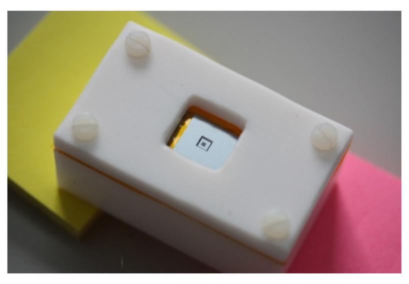
Miniature X-ray source concept

CNTs as field electron emitters

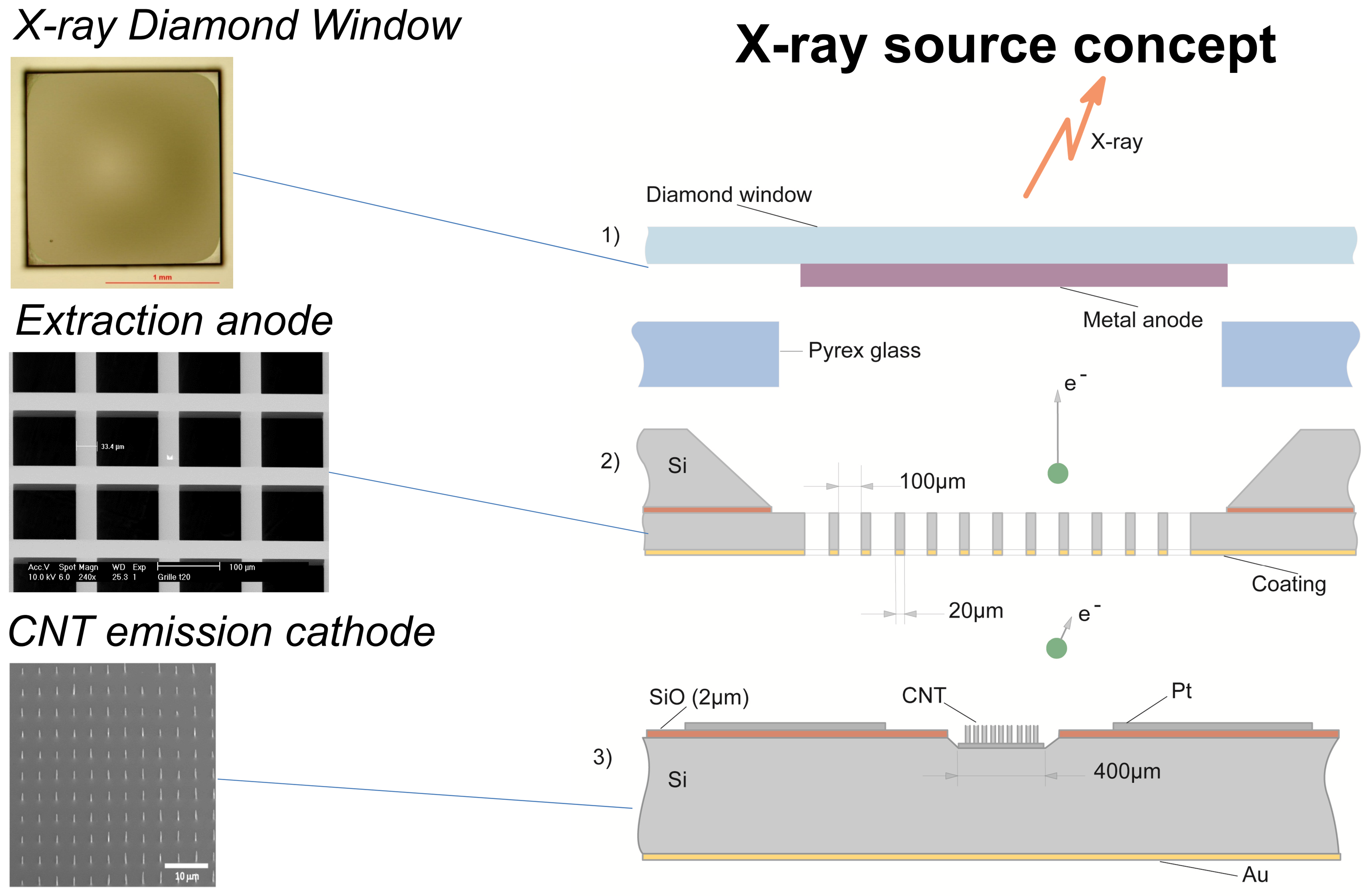
CNT Characteristics:
- Small diameter and high aspect ratio
- Large electrical field enhancement factor and low threshold voltage

→Miniaturization of X-ray source
→Pulsed operation of X-ray source



Mock-up of an CNT based miniaturised X-ray source

X-ray source concept

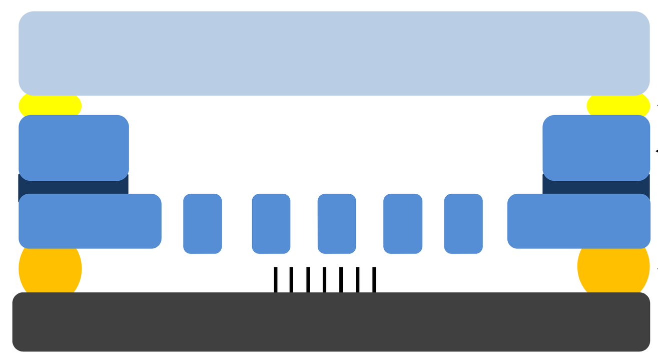


AuSn Transient Liquid Phase Bonding

Key requirement for bonding technology

- Hermetic packaging under **10^{-5} mbar** for functioning of CNTs
  - → Integration of getter material needed
  - → Getter activation : 15-30min at 350-450°C in a **sealed cavity**

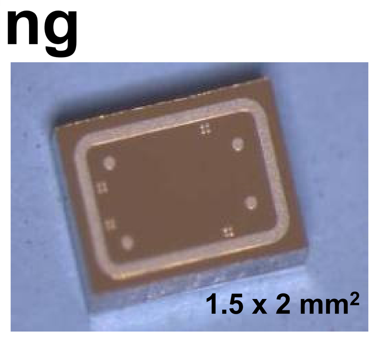
Bonding of CNT wafer and extraction grid based on AuSn TLP process

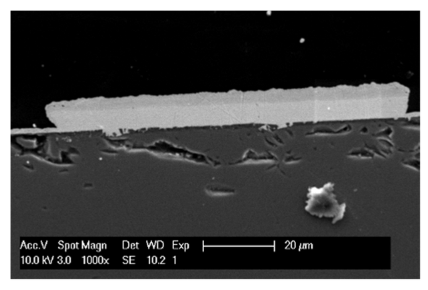


Au-Sn intermetallic compound formation leading to isothermal solidification at the bonding temperature

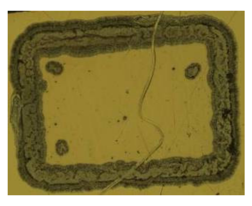
Solder fabrication and bonding

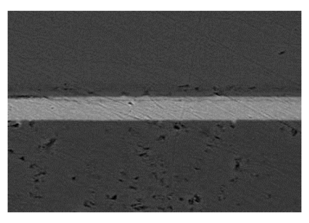
- Au/Sn multilayer electroplating on thin-film UBM





- Au-rich intermetallic achieved in the whole joint
- 4h annealed samples



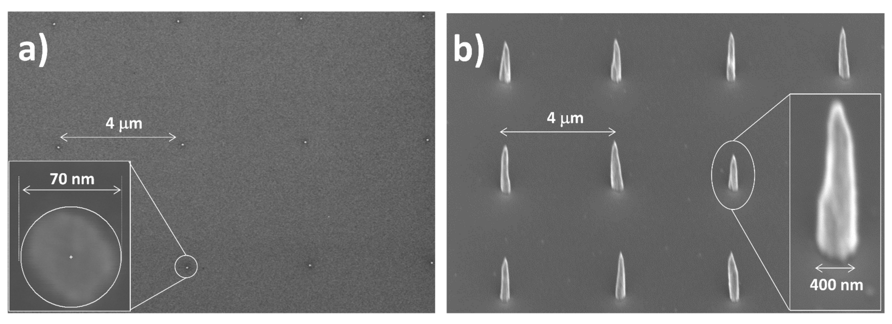


High bonding pressure
Continuous bonding line

CNT dies integration and vacuum measurements

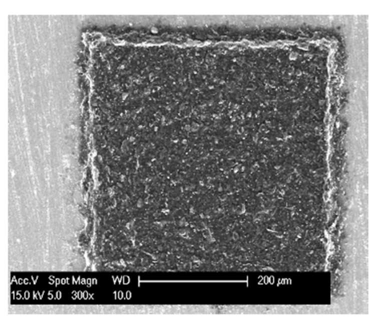
PECVD growth

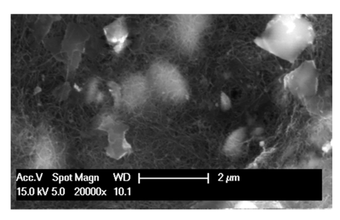
- CNTs grown by Plasma Enhanced Chemical Vapour Deposition (PECVD) on Ni nanodots (70 nm diameter)
- E-beam lithography of Ni nanodots arrays on TiN intermediate layer
- High growth temperature of 750ºC



CNT paste technology

- Screen printing of a carbon nanotube-clay composite paste on molybdenum substrates
- Annealing in vacuum at 880 °C

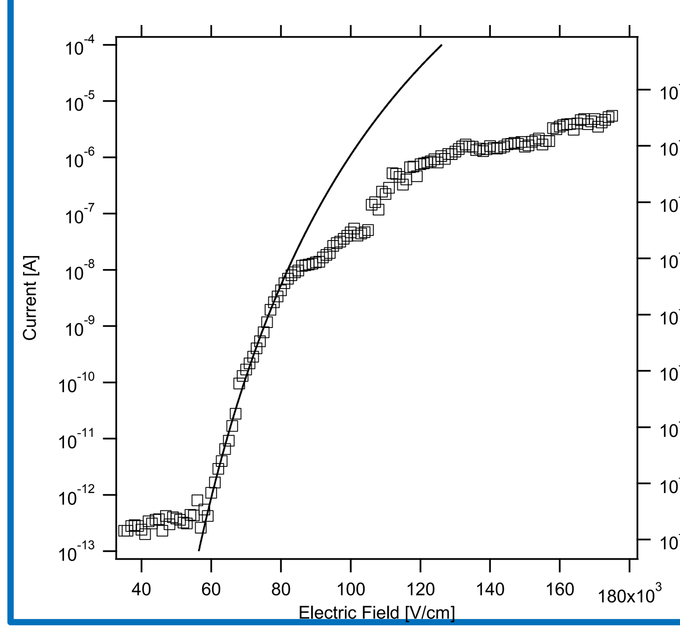




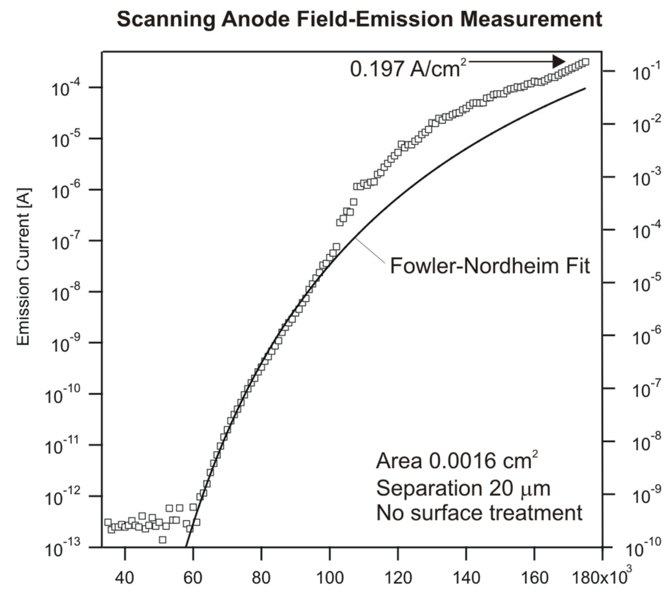
Electron emission of deposited CNTs

- Repeatable and stable electron emission over a long time (up to several hours) at constant high voltage supply

PECVD VACNTs electron emission

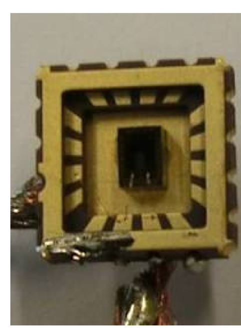


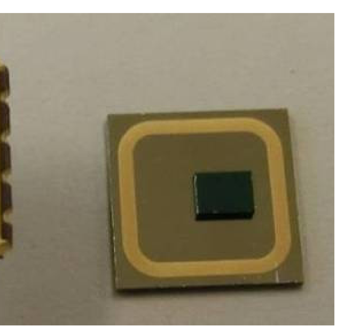
CNT paste electron emission

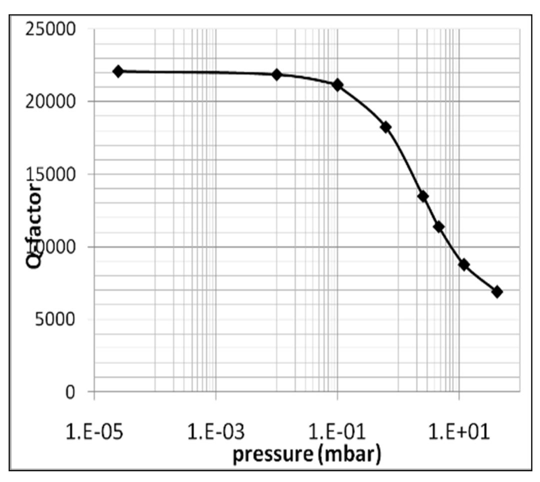


CNT outgassing experiment

- Harsh deposition conditions of CNTs could affect the outgassing/vacuum level
- CNT dies integrated into ceramic packages and sealed with AuSn eutectic preforms under vacuum (2mbar)
- µ-resonators used to measure the vacuum level







Vacuum results

- Q-factors in the range 13'400-13'600 (correspond to ~2mbar)
- No change observed after bonding (15 days)
- No visible difference between packages with CNT dies or without
- No influence of the CNTs on outgassing detected for this vacuum level