Thin film diamond thermistors for space environment applications

Miguel Neto, PhD

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Credit: ESA, NASA

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CICECO AVEIRO INSTITUTE OF MATERIALS

universidade de aveiro

Dep. of Materials and Ceramic Engineering
Dep. of Physics
Dep. of Chemistry

Credit: ESA, NASA

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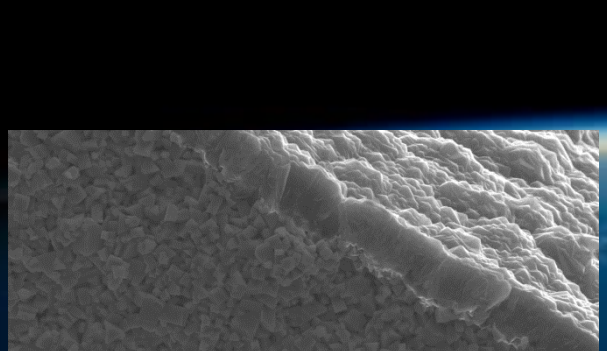
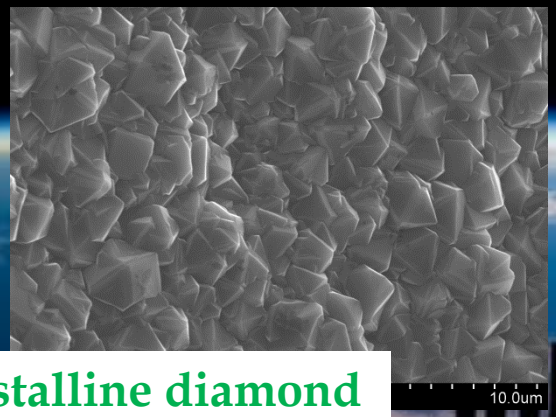
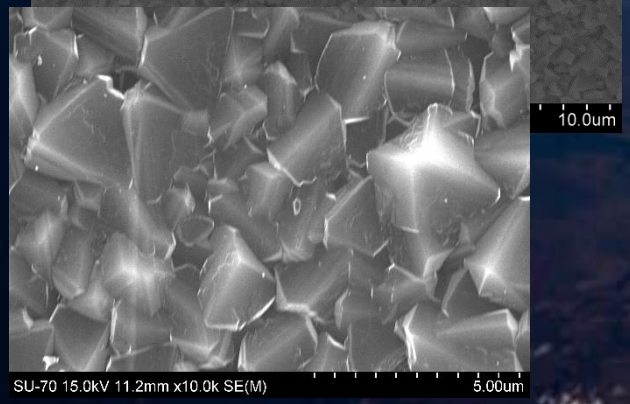
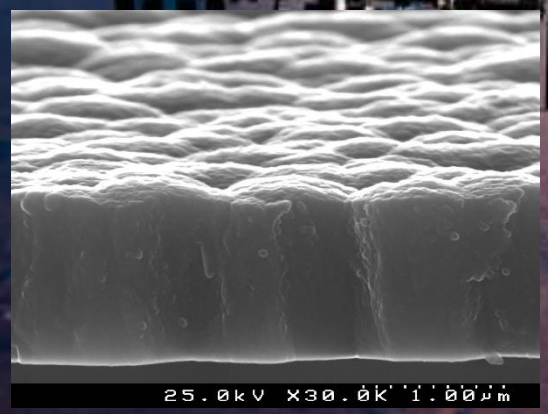




Microcristalline & Nanocristalline diamond





Sensors

- Fast response time
- High sensitivity
- Wide T interval
- Radiation proof
- Mechanically tough
- Erosion resistant
- Oxidation resistant
- Contactless!!

New sensors?! ← **Diamond?!** ← **CVD films & coatings**

Credit: ESA, NASA

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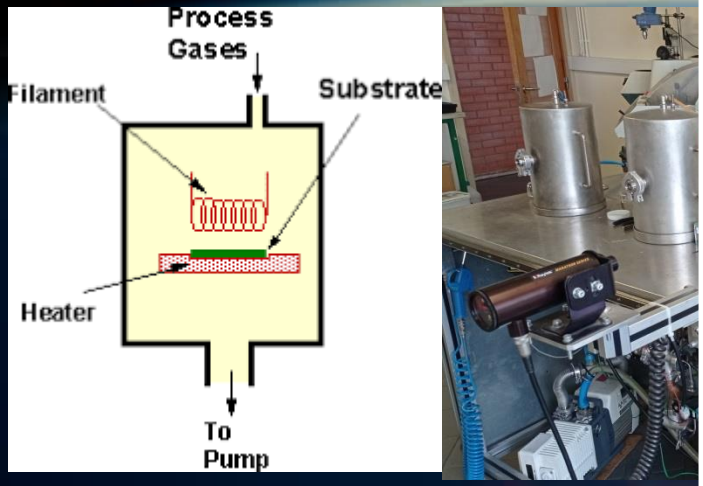
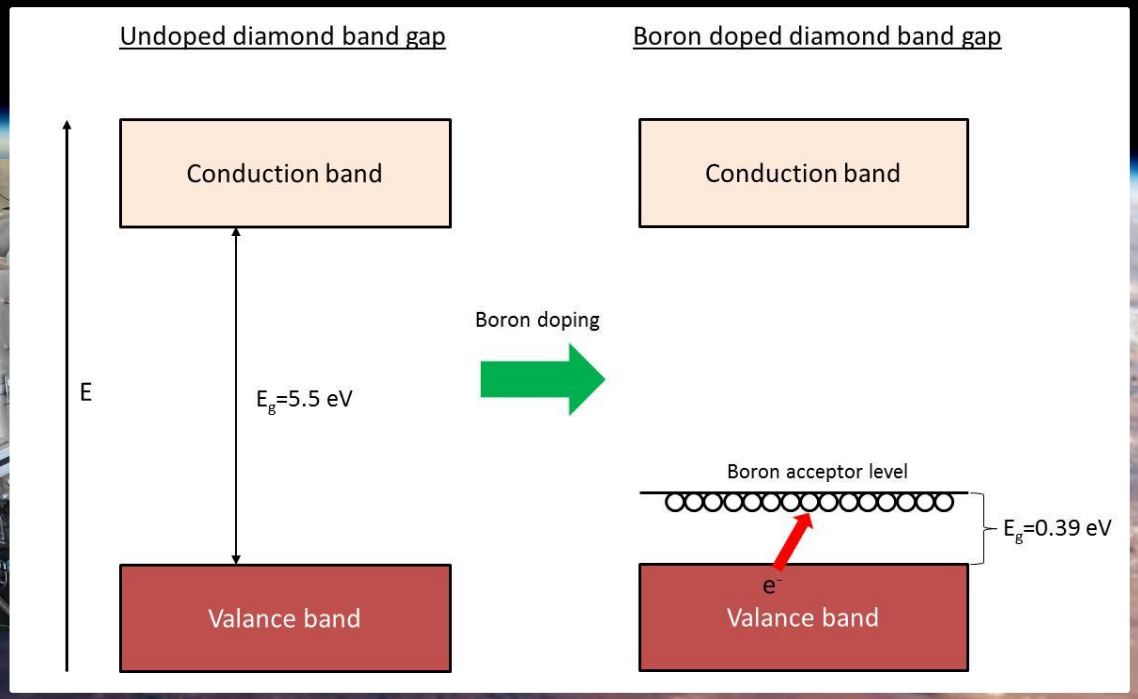
HF-CVD





Intrinsic CVD diamond is an electric insulator (~10^{18} Ω.m)

NOT good!!!

Boron doping produces p-type CVD diamond with R(T)

NTC thermistor

Credit: ESA, NASA

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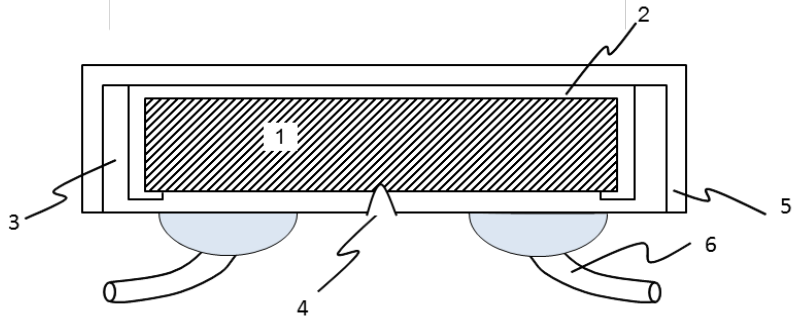
Diamond thermistor

Cross-section



1 – Si_3N_4 substrate
2 – Boron doped diamond
3 – WC layer
4 – Groove
5 – Undoped diamond
6 – Electrical leads

- Hardness
- Refractory
- Dielectric
- Diamond adhesion

- Ohmic
- Simple
- Refractory
- Diamond adhesion

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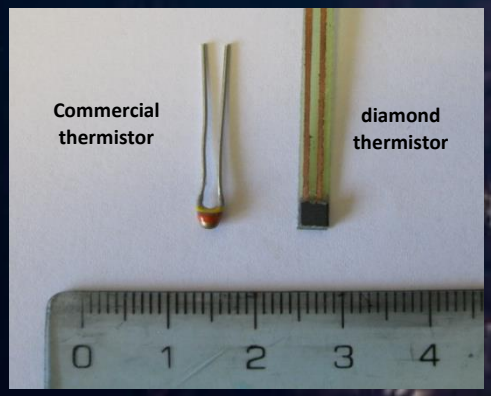

Thermistor	CH_4/H_2 flow ratio	Ar flow (ml/min)	Pressure (mbar)	T_f (ºC)
TA	0.023	5	100	2200
TB	0.038	5	75	2190

Same B doping (99% pure B_2O_3 diluted in ethanol 10000ppm)

Credit: ESA, NASA

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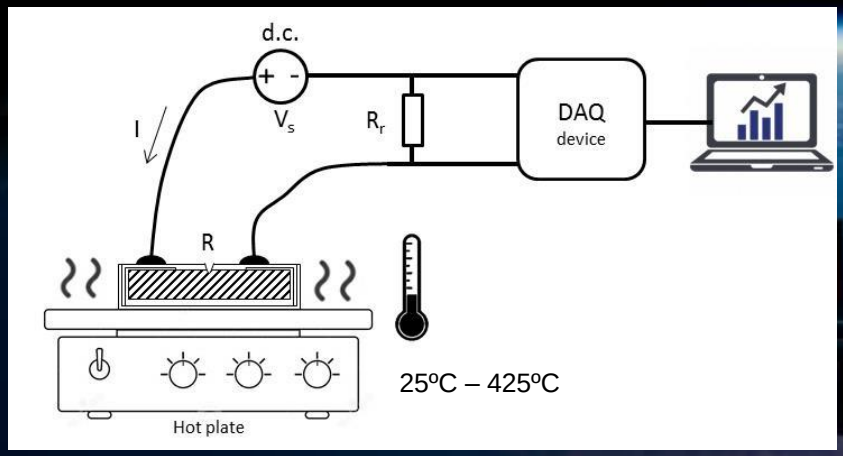
Thermal contact

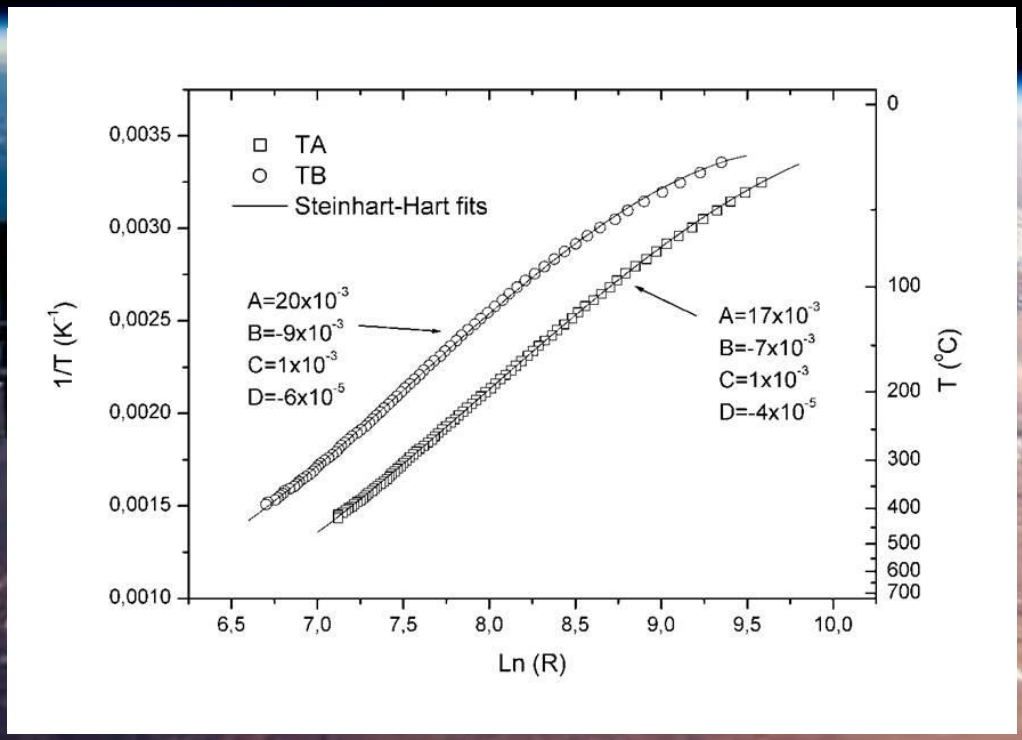


Steinhart-Hart

$$1/T = A + B*\ln(R) + C*\ln(R)^2 + D*\ln(R)^3$$

$$\beta = \ln(R_1/R_2)/(1/T_1 - 1/T_2)$$

Thermistor	β (K) [25-85ºC]	β (K) [85-425ºC]
TA	1700	1250
TB	2000	1200



Diamond & Related Materials 109 (2020) 108036

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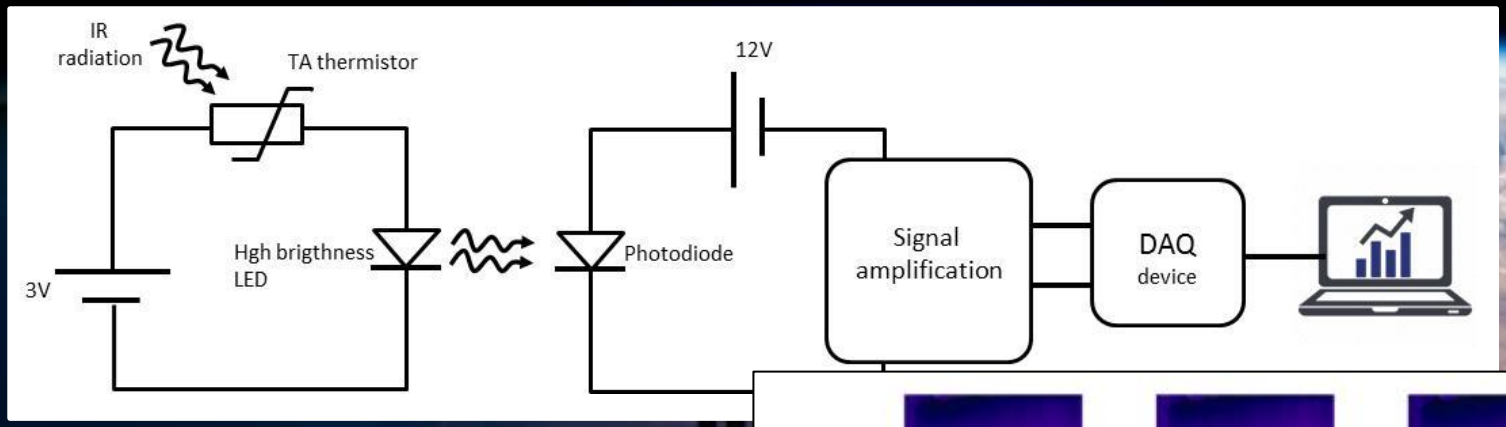
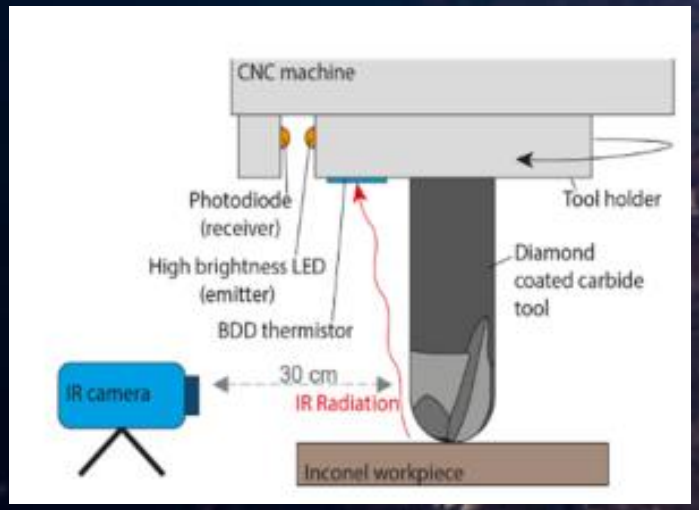
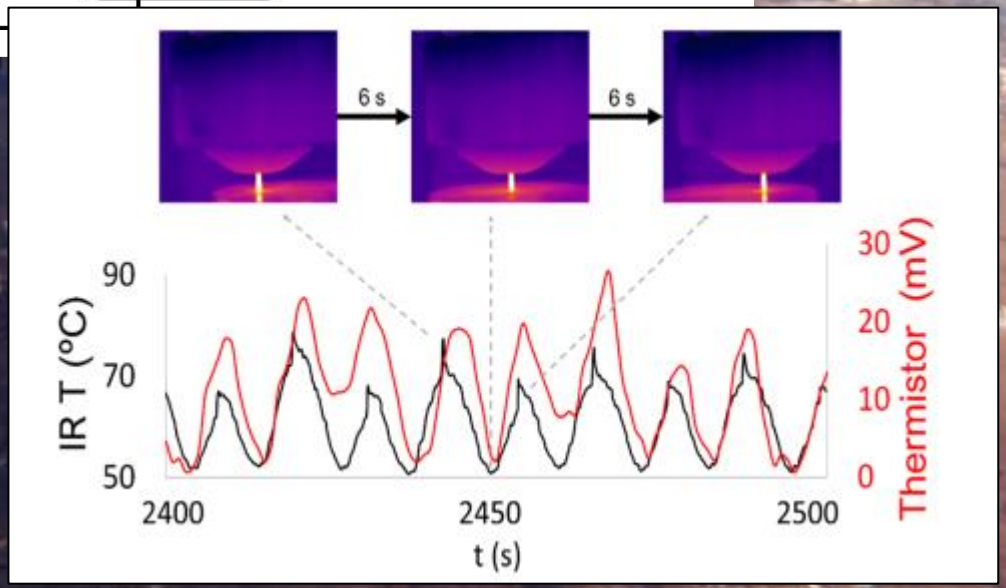
Contactless - IR detection







Credit: ESA, NASA

Materials **2021**, 14, 7334

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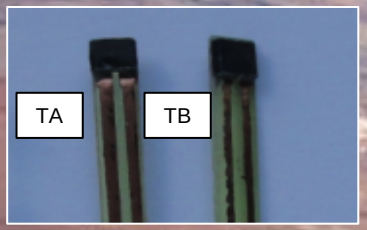
Conclusions

- ✓ NTC diamond film thermistors were produced
- ✓ Whell adhered ohmic contacts
- ✓ β values similar to commercial sensors
- ✓ Sensitivity to IR radiation - contactless applications

Harsh environments: Space exploration



- Vehicles - launch and reentry;
- LEO;
- Deep space;
- Surface activities on the Moon and on Mars
- etc…

Credit: ESA, NASA

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Challenges

- ? T limits – atmosphere & vacuum
- ? Ionizing radiation
- ? Space hardware integration
- ? Certification: ESA, NASA, etc.

Collaboration!!!!

Industry

Research

Organisations

Credit: ESA, NASA