# Validation of Titanium-Gold and Titanium-Silver and Copper Contacts on CVD Diamond Sensors for Beam-Conditions Monitors and Tracking Detectors for Heavy Ions under Proton Irradiation ◇

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## 1. Introduction

For monitoring purposes at hadron accelerator beam lines, such as the Large Hadron Collider at CERN, and heavy-ion experiments, chemical vapor deposition (CVD) diamond is more and more used as a radiation resistant sensor material. In order to validate the durability of metal contacts under irradiation, two different systems (Titanium-Silver and Titanium-Gold with a glued-on copper strip) were exposed to $10^{15}$ protons/mm$^2$ at an energy of 25 MeV over a period of 18 hours. Although the diamond bulk suffered from radiation damage, it could be demonstrated that both contact systems maintained their ohmic properties and will thus depass the lifetime of the diamond sensor itself.

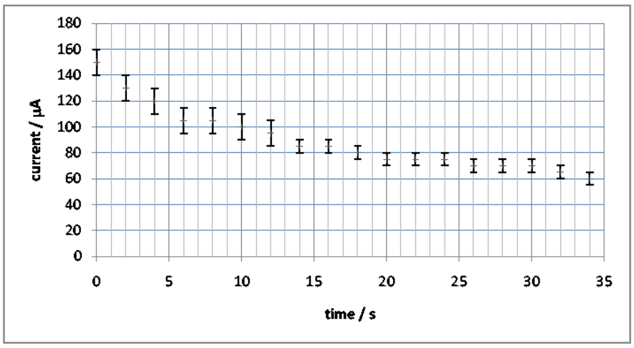


Fig. 1: Decrease of the current signal from the diamond during exposure to 25 MeV protons at 10 $\mu$A beam current over a spot of 4 mm$^2$.

## 2. Contact properties and setup

The CVD diamond sample used in the irradiation test was a prototype sensor for the Beam-Conditions Monitor of CERN's LHCb experiment [1], 500 $\mu$m in the direction of the beam, and 10 mm × 10 mm in surface. A metallized area of 8 mm × 8 mm covered the central part on both sides of the sensor. Upstream, with respect to the beam direction, the contact was made of a 500 Ågold layer with 500 Åof titanium as the undermetal. For the downstream contact, the gold layer was replaced by a silver layer of 500 Å, respectively.

The electrical contact was established with a glued-on copper cladded HFS[1] strip [2], using Epotecny E205 conductive glue [3]. Initially, the resistivity of this contact system was measured to be below 1 Ω.

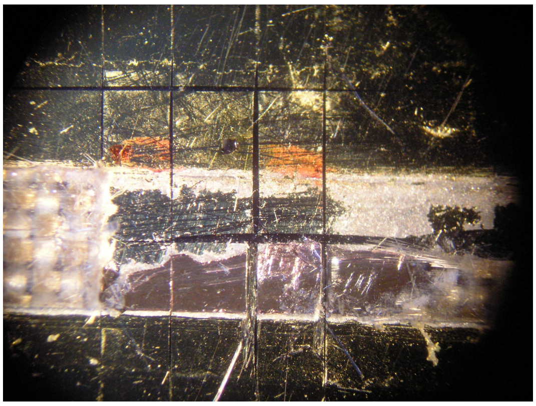

Fig. 2: The Au/Ti metallization after exposure to 25 MeV protons, after cuts with a dicing saw were applied for the electrical separation of exposed and non-exposed parts.

## 3. Results

After an exposure to $10^{15}$ protons/mm$^2$ from the Tandem accelerator at an energy of 25 MeV shined on a surface of 4 mm$^2$, both contacts maintained their ohmic properties. In order to make sure that no current flew over an unirradiated part of the contact, the metal surface was cut with a dicing saw, as shown in Fig. 1.

Despite the fact that the metallic contact was still operational after exposure, showing no measurable degradation, the current signal from the diamond, measured by MICRO-CSA charge-sensitive preamplifier, had completely vanished. Over 34 minutes this effect was further studied at a previously unexposed spot of the diamond sensor. The current decrease is shown in Fig. 1.

## 4. Conclusion

The electrical properties of both contact systems that were tested were maintained after exposure, nevertheless, the diamond bulk itself was severely damaged. This should be subject to further investigation.

### References

[1] Ch. Ilgner *et al.*, Implementation of a diamond-beam-conditions monitor into the LHCb experiment at CERN, Nuclear Science Symposium Conference Record 2007.

[2] IST - Ionen Strahl Technologie - GmbH, Ballerslebener Weg 4, 06484 Ditfurt, Germany, www.istechnologie.de, Adhesiveless Basic Material for Flexible HF and Microwave PCBs, data sheet, no date, no place.

[3] Epotecny, 9 rue Aristide Briand, 92300 Levallois Perret, France, www.epotecny.com, Electroconductive Epoxy Resin E205, data sheet, no date, no place.

[4] R$^3$B-Collaboration, Technical Proposal for the Design, Construction, Commissioning and Operation of R$^3$B, Dec 2005

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[1] HFS is the trade mark for a novel, adhesiveless copper-clad PTFE-film with improved properties regarding peel strength, thermal stress and flexural endurance designed for microwave applications up to 100 GHz. The copper cladding had been applied to the substrate by the manufacturer using a galvanic process after heavy-ion irradiation.See reference [2].