TiN coating, experience, pros and cons.

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Our experience with TiN is not too rich.
Within PIP-II project we coated and tested two type of couplers:

- Two RFQ, 162.5 MHz couplers made by Mega company.
- And three first 325 MHz couplers made by Omley company.

As we know, Omley sent coupler to the Japan for TiN coating.
Mega coated ceramic in local university.

We could not control a quality and thickness of coatings and had to rely to manufactures.

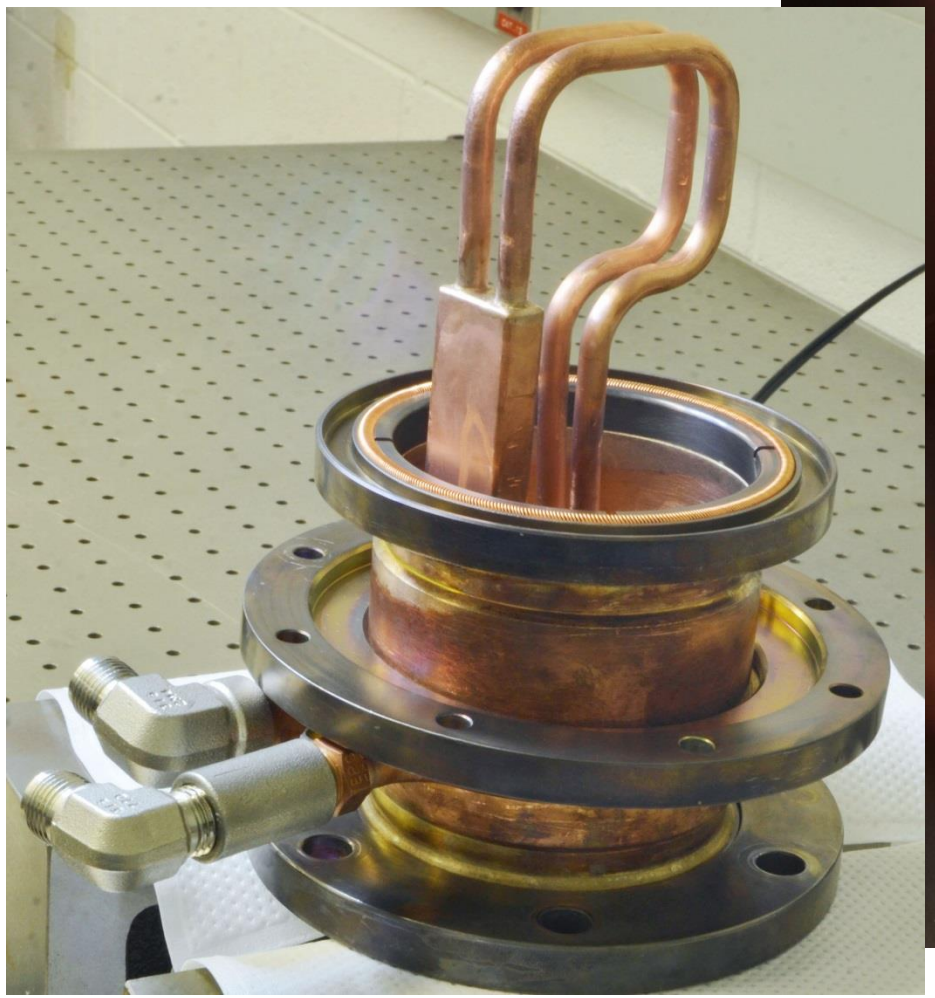
- Two Omley coupler were tested at room temperature test stand and one was tested with SSR1 cavity.

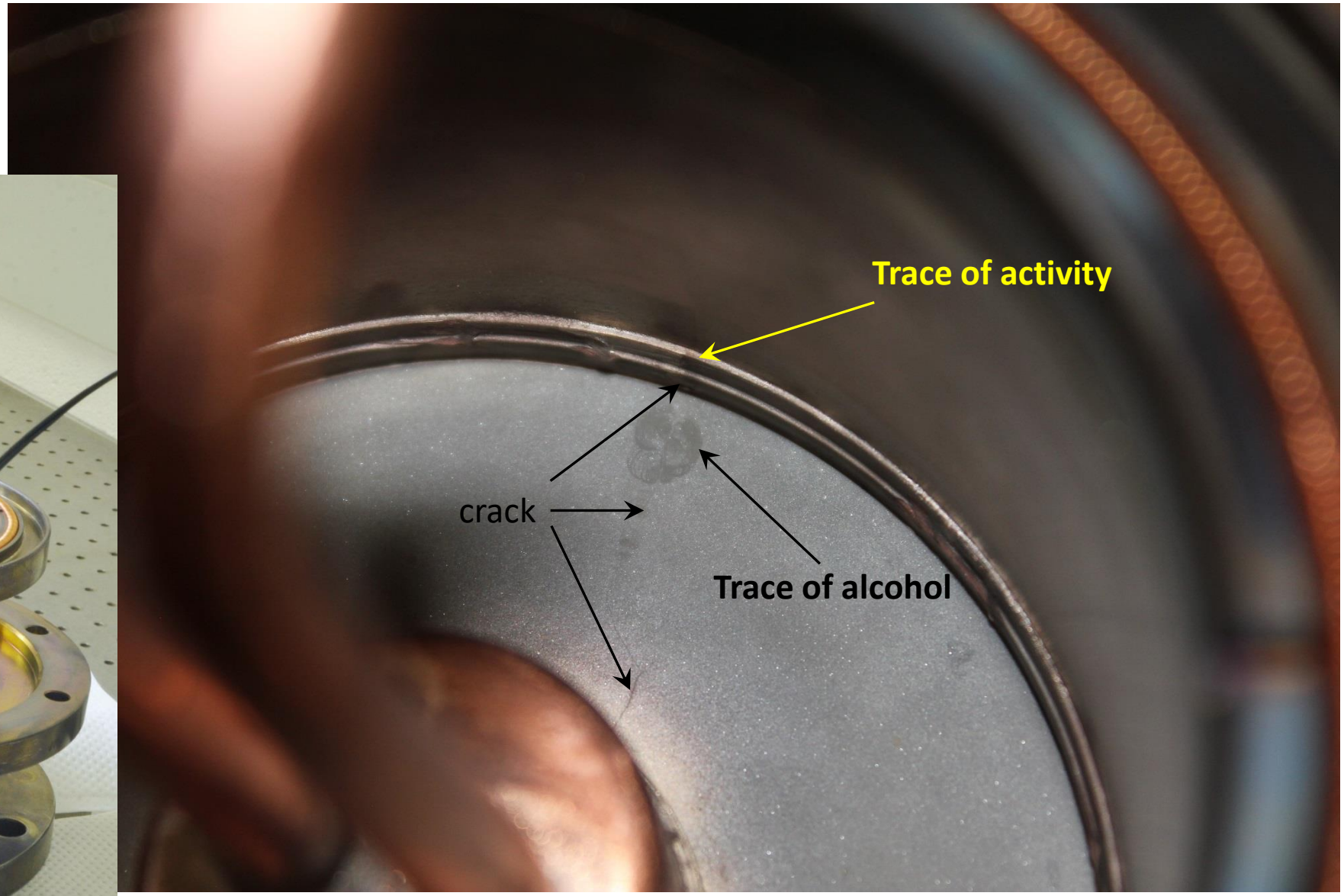
Nothing special was noticed in couplers behavior.

- Experience with RFQ couplers was not so positive:

Bias current was detected after some time of operation. Current was detected without RF power.
It means the surface of ceramic became conductive. After opening the conductivity disappeared,
but color of ceramic was drastically changed: from white it became gray.
We do not know what happened: was it too thick TiN coating and TiN transmuted to pure Ti under electron bombardment or it was some additional deposition.

RFQ window, ceramic is broken.





- After that we decided not coat ceramics at all. According to simulations and later to experiments, a multipactor can be successfully suppressed by HV bias.

- New windows (and with new configuration) were made for RFQ without coating. Up to now they works well without any signs of multipactoring (with bias) and without bias current. Windows are still installed to RFQ and we cannot tell anything about color of surfaces.

- More then 10 of 325MHz couplers without TiN were tested at room temperature test stand at power level 10 -20kW. Multipactor was suppressed by ~3.5 KV bias successfully.

- More then 8 of 325 MHz coupler without TiN were tested with superconductive cavities at STC at power level 5-10KW. Multipactor was successfully suppressed by bias.

- 8 couplers without TiN are installed into SSR1 cryomodule waiting for test.

Pros and Cons of TiN coating.

Pros.

Reduce secondary emission from ceramic surface. Coupler can operate without bias after RF conditioning (sometimes after very long RF conditioning).
Probably TiN coating can prevent or reduce charging of ceramics by charged particles coming from cavity.
We have no relabel data of this phenomena, problem has to be investigated. We know one negative experience from China: coated window was destroyed by field emission current coming from cavity.

Cons.

Additional operation. Additional money and additional possibility to make mistake.
Difficult to find qualified manufacturer(Omley sent windows to Japan)
Difficult (or impossible) to check a thickness of coatings.
Thick coating can cause of additional losses, window overheating and window break.

What we decided to do.

- Main warry is impossibility to control a thickness and a possible high losses at ceramic surfaces.

We decided to learn how to measure additional the RF losses caused of coating and check them during a production. We suppose to ask company to coat spare ceramics disks the same way they do for real window with antenna. Then ‘loss tangent’ will be measured and compared with uncoated loss tangent.
It seems we cam measure loss tangent with accuracy ~ 1e-5.

- Because the TiN coating is last operation, all window will be manufactured without coating and will be coated after if it is necessary.