Low T N doping / N infusion cavity development at DESY

- **1.** N Infusion Reminder
- 2. Baseline Single Cells
- 3. Furnace & Procedure
- 4. Results
- 5. Summary

Marc Wenskat (on behalf of many!)

TTC Workshop 2017 East Lansing, 21. 2.2017





Nitrogen Infusion – Fermilab's discovery



[[]A.Grassellino, S. Aderhold - TTC Saclay 2016]



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Retested 2016

- Qvs. T
- Q vs. E at different T





> Prior to Test 4: HPR after storage and HF rinsing



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Prior to Test 4: HPR after storage and HF rinsing >



Some processing (2·10⁻³ mGy/min) on first 2K curve Marc Wenskat | TTC Workshop – East Lansing | 21.2.2017 | Slide 12 >



Final 2K curve: FE with 1.5.10⁻⁴ mGy/min (last three datapoints) >

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Furnace / N2 venting

- > 2 turbo molecular pumps (Varian, 6000 l/s each , max. intake pressure ~ 10⁻² mbar)
- T_{max} ~ 1320°C
- V = 1800 x 625 x 660 mm³





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Penning gauge (standard)

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Full range gauge (new installation)

Penning gauge (standard)

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> After test 4: additional HPR and RF test 5



N. Krupka – MKS3^{Marc}

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- > T-sensor installed on cavity
- > Add. 2 samples



Full procedure





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Full procedure





Full procedure



1DE18 – Results – Q vs E



- 1) warm up across T_c to check for frozen flux
- 2) warm up to 150K and fast cool down



1DE18 – Results – Q vs T



SEM/EDX of DESY Samples: No Ti detected



no Ti detected at E_{acc}=10-20 kV (mapping over area)



Precipitations known – β-Nb₂N – from doping



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- When are they formed?



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- When are they formed? ٠
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- When are they formed?
 - N_2 pressure = 6x10⁻⁸ mbar @ 800°C
 - Nb inert below 350°C against N



151.8 nm



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- > Decision on / preparation of more single cells
- Baseline RF test of four 9-cell HiGrade cavities
 - Prepared & test will happen this/next week





RGA @ 800°C (0h)



RGA @ 800°C (1h)



RGA @ 800°C (2h)



Nitride formation



[Fromm & Jehn, "Reactions of niobium and tantalum with gases at high temperatures and low pressures", Vacuum 18(4), p. 191-197, 1969]

1DE18 – History

- Ningxia Nb (RRR=300) fine grain (2005)
- Deepdrawing @ RI (then Accel)
- Machining, EBW @ DESY
- > BCP @ Accel, EP @ Henkel
- > Assembly, HPR & test in Hall NO
 - Test 1 after 100µm EP, HPR, 141C/12h bake, HPR (28.3.2007)

 E_{acc} = 22.6 MV/m@ Q_0 = 1,3 ·10⁹; lim. by FE, strong FE

Test 2 additional HPR (6.6.2007)

 E_{acc} = 38.3 MV/m@ Q_0 = 5,3 ·10⁹; lim. by BD, still strong FE

Test 3 additional HPR (20.6.2007) no FE

 E_{acc} = 39.5 MV/m@ Q_0 = 1,2 ·10¹⁰; lim. by BD, <u>no FE</u>

• Test 4 additional HPR after storage and HF rinsing (remove oxides) (25.8.2016)

 E_{acc} = 36 MV/m@ Q_0 = 4,8 ·10⁹; lim. by PWR, some FE



1DE18 – Q vs E - Hist





1DE18 – Q vs T - Analysis

	Test 1 after 100µm EP, HPR, 141C, 12h bake, HPR	Test 2 add. HPR	Test 3 add. HPR	Test 4 add. HPR
R _{res} fit	4.3 nΩ	$3.7~\mathrm{n}\Omega$	$3.7~\mathrm{n}\Omega$	3.4 nΩ
∆/k _B T _C (T _C = 9.2K)	1.95	1.94	1.91	1.97
Q _{BCS} (4.3K)	6.4 ·10 ⁸	6.76 ·10 ⁸	6.7 ·10 ⁸	6.8 ·10 ⁸
Q _{0.max} (1.8K)	3.9 ·10 ¹⁰	4.4 ·10 ¹⁰	4.1 ·10 ¹⁰	4.3 ·10 ¹⁰
Q ₀ (E _{acc} = 23.5 MV/m; 1.8K)	-	2.9 ·10 ¹⁰	2.5 ·10 ¹⁰	3.1 ·10 ¹⁰





1DE21 – Q vs. E History



Test 3: E_{acc} = 23 MV/m@ Q_0 = 1,9 ·10¹⁰; lim. by BD; no FE



1DE21 – OBACHT



1DE21 – OBACHT





1DE17 – Q vs. E History



strong FE after 21MV/m - processing (2h) at last point \rightarrow improved performance





[Grassellino – arXiv:1305:2181]



> First suspicion: Q-Disease



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- Not confirmed
- 10 HF rinse (20nm removal) no recovery
- EP (20 µm) recovery

Note: 5 μ m seemed to be sufficient for other cavities with same history



[Grassellino – arXiv:1305:2181]



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Sample studies

- Precipitation at grain boundaries
- Only on one sample side
- EDX & XPS studies Titanium remnants



[Grassellino - arXiv:1305:2181]

