MgB_2 work at LANL in collaboration with KEK

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KEK: Hiroshi Sakai, Takafumi Okada, Eiji Kako, Kensei Umemori, Taro Konomi

LA-UR-20-20982

Outline

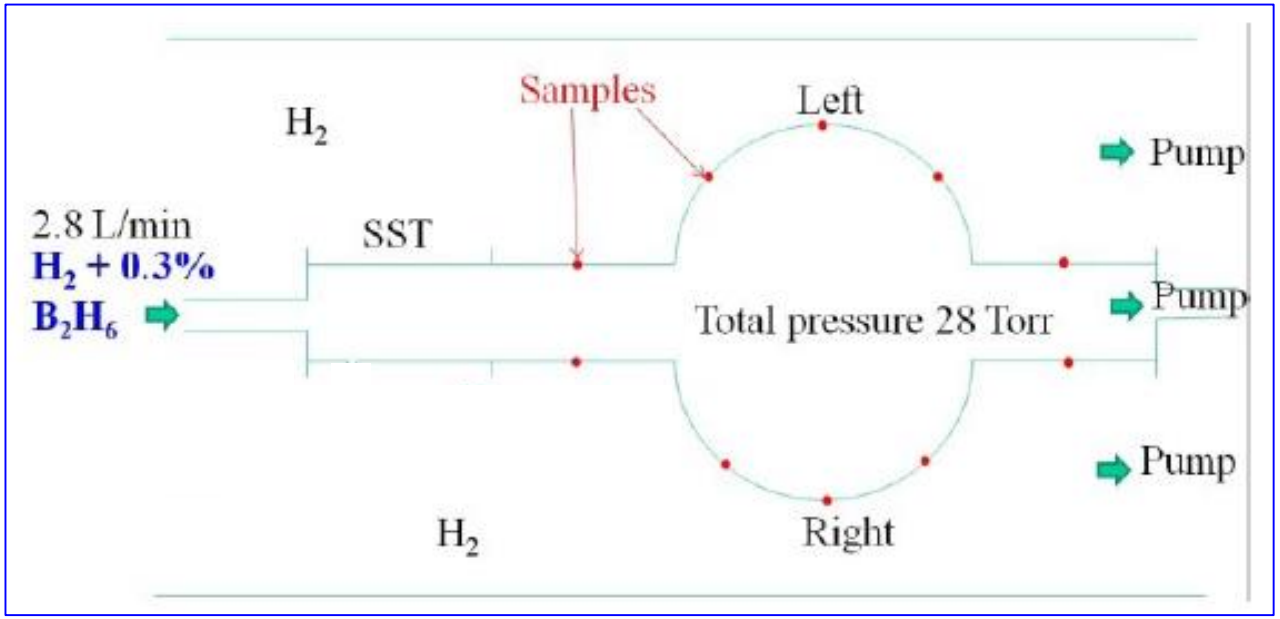
- A short description of the coating technique developed at LANL.
- Recent test results
- Design of the coating system to coat 1.3 GHz elliptical cavities.

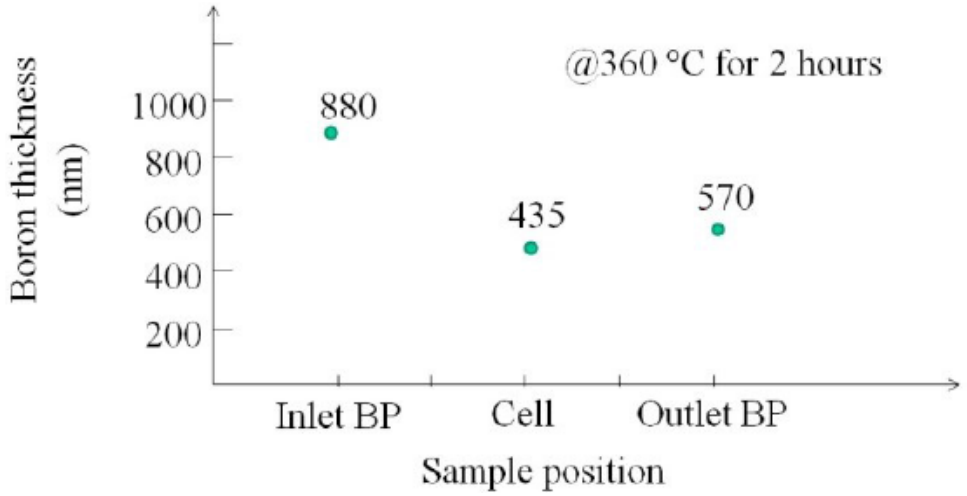
LANL coating technique

- LANL had a project on MgB_2 from 2010 - 2015. They developed a technique to coat boron (B) first, then react it with Mg vapor (2-stage process). [e.g. Tajima et al., SRF2015, p. 700]
- They restarted the MgB_2 work as a US-Japan Cooperation Project in 2018.
  - Since they lost the large furnace and equipment at TA-35 that were used in the previous project, they started to design a new coating facility at TA-53 (Tsuyoshi's lab) based on their previous experience at TA-35.
  - In November, 2019, they restarted experiments to optimize parameters for B and Mg reaction using a small system at TA-53 and the B samples obtained in the previous project.

LANL coating technique (1st stage: coating of B layer)

- Flow B_2H_6 gas inside the cavity while keeping the cavity surface at a temperature 250 – 400 °C.
- The B_2H_6 decomposes and a B layer is formed on the cavity surface.
- By controlling the temperature, deposition rate can be controlled, i.e., the higher the temperature, the higher the deposition rate. Thereby the thickness profile can be controlled.
- Usually, cell is thinner than beam pipes.





If the Inlet BP temperature is lower, e.g., 250 °C, the thickness can be reduced.

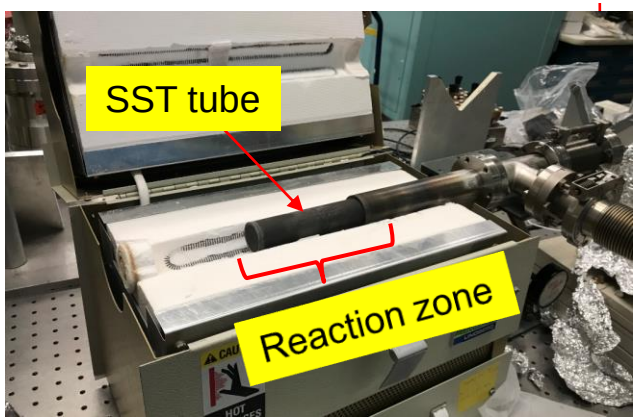
LANL coating technique (2nd stage: reaction of B layer with Mg vapor)

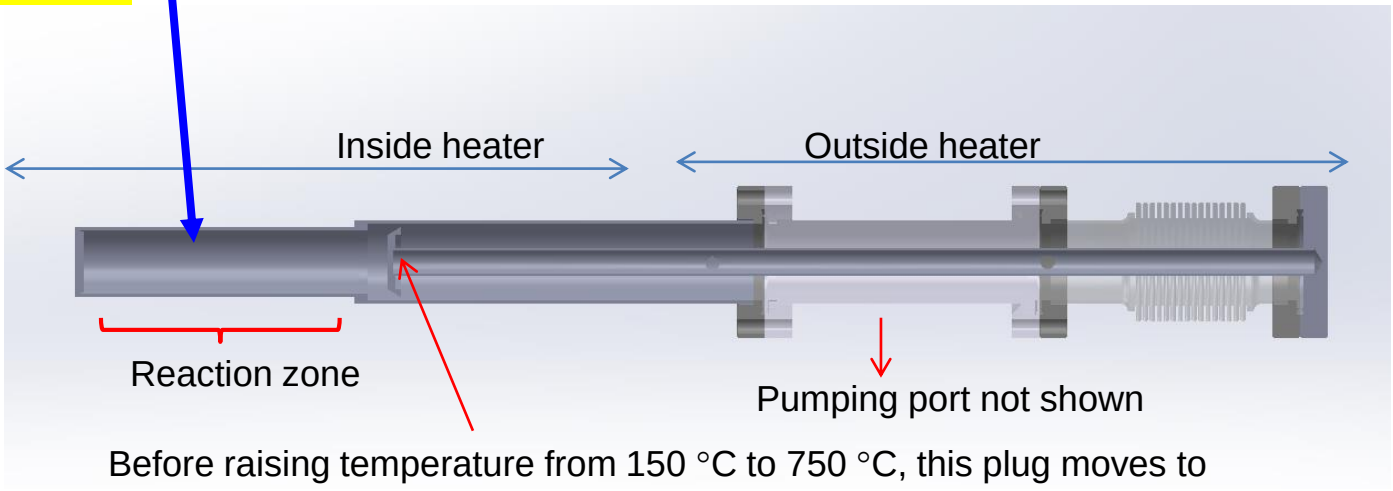
- Prebake the system up to 200 °C under vacuum.
- Cool down to room temperature, add Mg pellets, bake out the system at 150 °C for >1 h under vacuum.
- Fill the chamber with UHP Ar gas up to 1/3 psi
- Plug the reaction zone to confine Mg vapor
- Heat it up to a planned temperature such as 750 °C and hold it at the temperature for planned period of time.
- Cool down the system fast enough to prevent formed MgB_2 from decomposing.

The B films obtained from the previous project

- The previous project used a 1.3 GHz elliptical 1-cell cavity with coupons attached on inlet and outlet beam pipes and cell equator.
- 22 coating runs at TA-35 were performed during the previous project and most of unused samples have been kept in a vacuum desiccator. Most samples have pure B or B with <15 % Mg, 100 – 1000 nm thick.
- They are stored in 3 carriers with each carrier having 81 samples of 6 mm x 6 mm with either sapphire or Nb substrate.
- The sample designation is carrier # - column row # such as 2-B4.

We restarted the test that ended on 28 June 2015 (run 15)

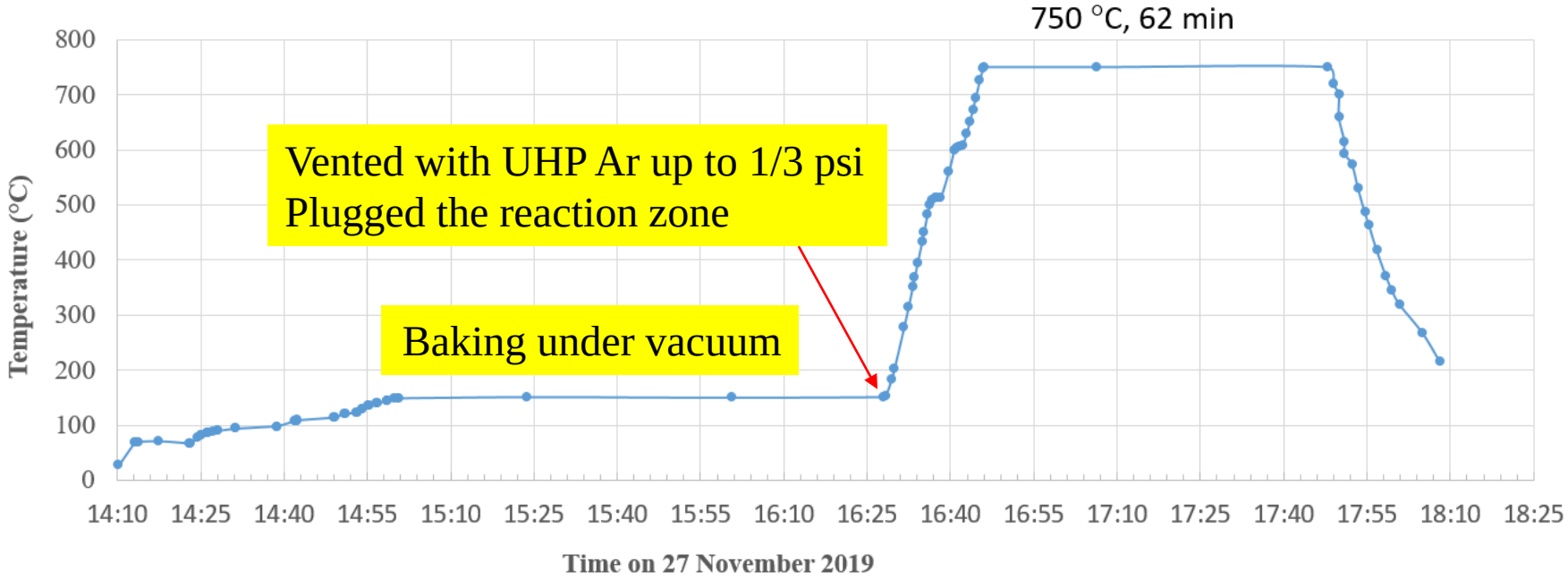




Before raising temperature from 150 °C to 750 °C, this plug moves to left and closes the hole to confine the Mg vapor

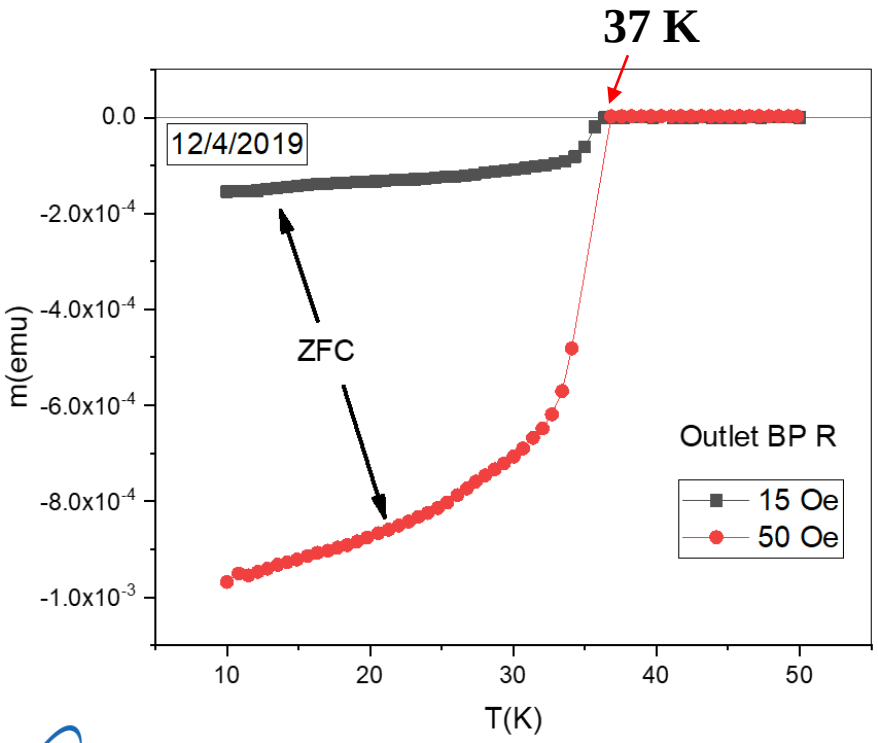
Recent 2 tests to produce MgB_2 film by reacting B film with Mg vapor

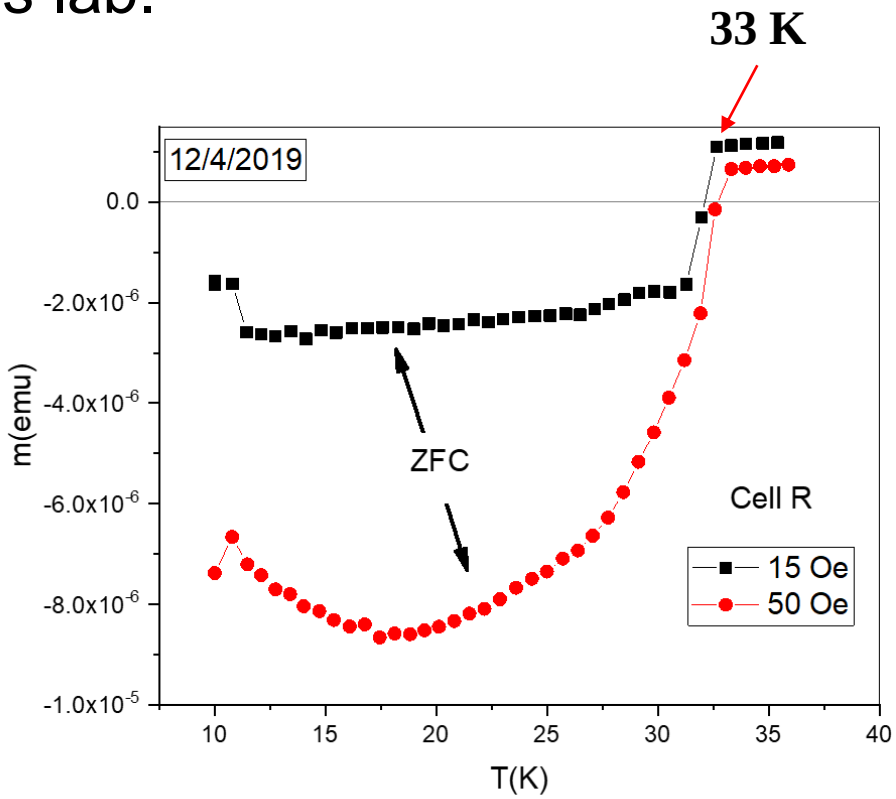
- TA-53 Run 16 on 27 November 2019
  - Hiroshi Sakai and Takafumi Okada from KEK joined LANL workers (Tsuyoshi Tajima and Paolo Pizzol)



Magnetometer measurement to check superconductivity

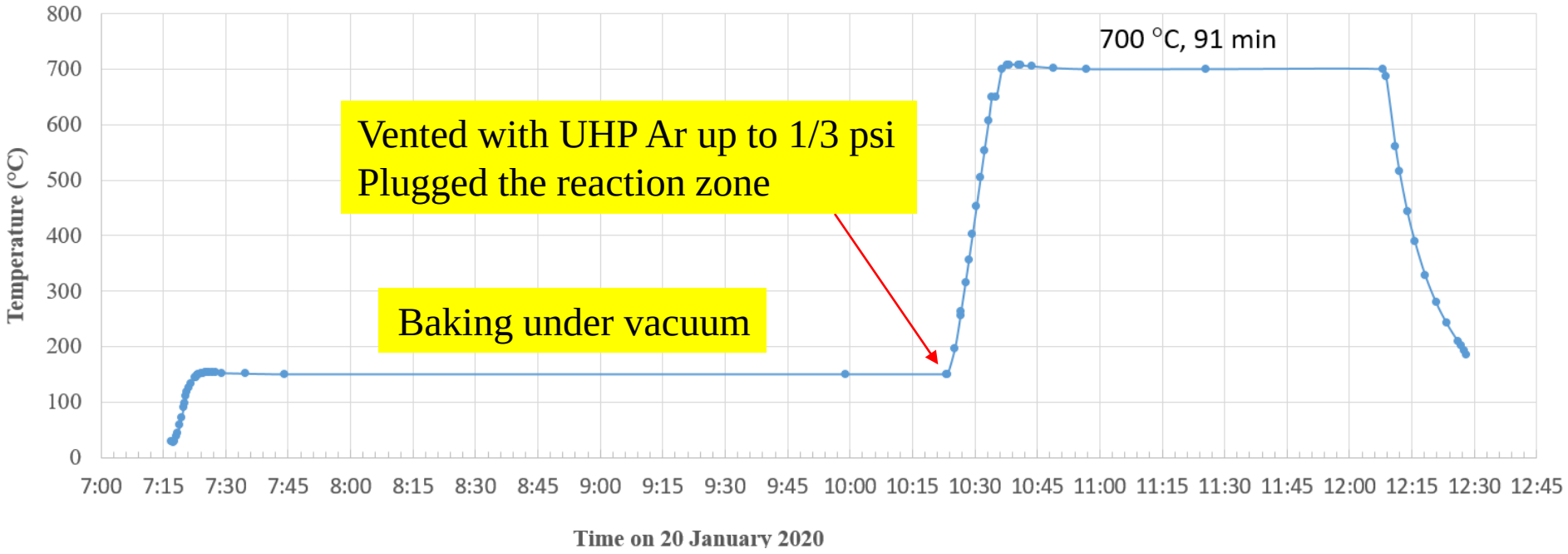
- This was carried out by Ivan Nekrashevich and Leonardo Civale at TA-3 in Leonardo's lab.





Recent 2 tests to produce MgB_2 film by reacting B film with Mg vapor (cont.)

- TA-53 Run 17 on 20 January 2020
  - Tsuyoshi Tajima did it on his own.



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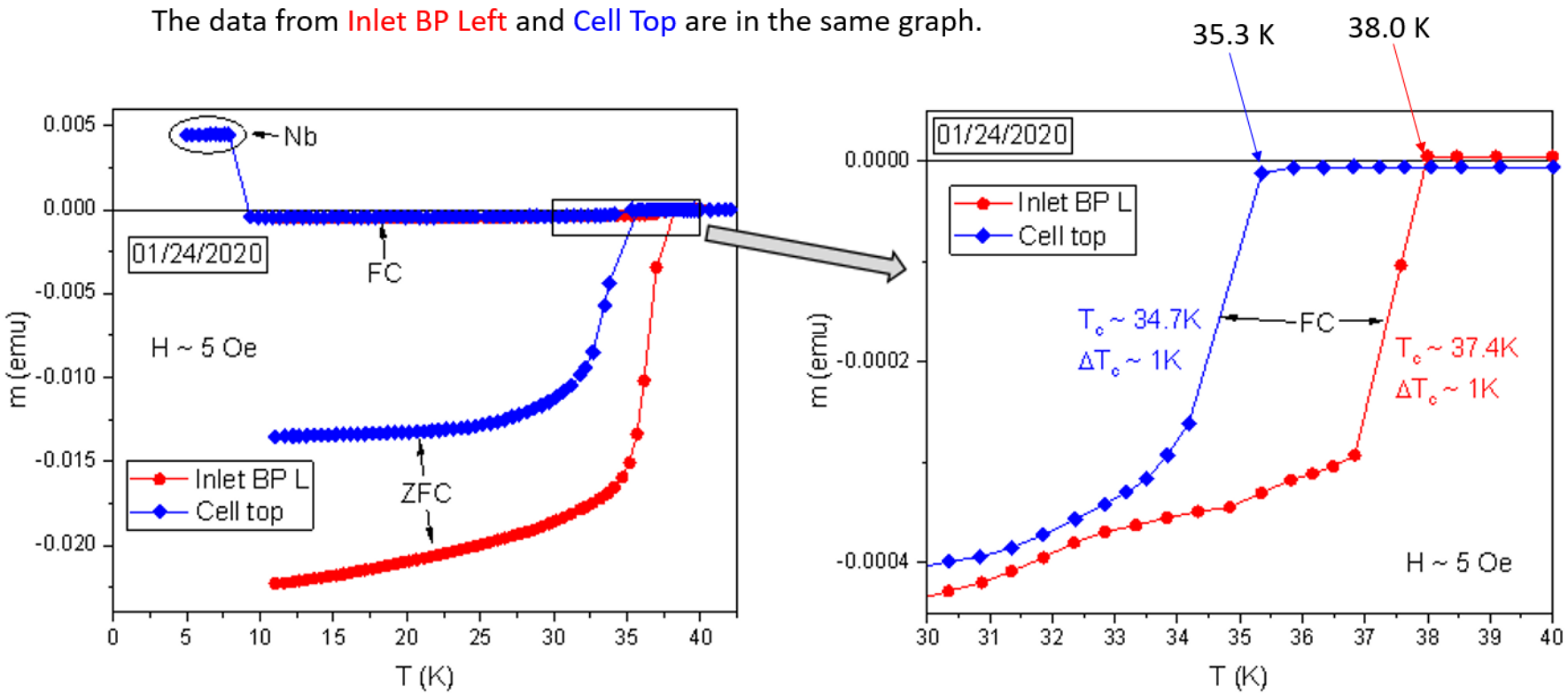


Summary of recent tests and next steps for parameter optimization

- We were able to reproduce the 750 °C result obtained in 2015.
- The test result at 700 °C was as good as that at 750 °C. (No test at 700 °C in 2015)
- Cell samples showed 3-4 K lower T_c . Need to identify the reason.
- Will test at 650 °C for 1.5 hours to check if we can reproduce the result in 2015 (T_c ~ 32 K at outlet BP top)
  - If T_c is >35 K, try 600 °C test.
  - If T_c is <35 K, try 650 ° for 3 hours to see if T_c goes up with long reaction time.
- Will test longer cooling time at the lowest reaction temperature that gives T_c > 35 K.
- Will start sample characterizations using AES/XPS from around April or May.

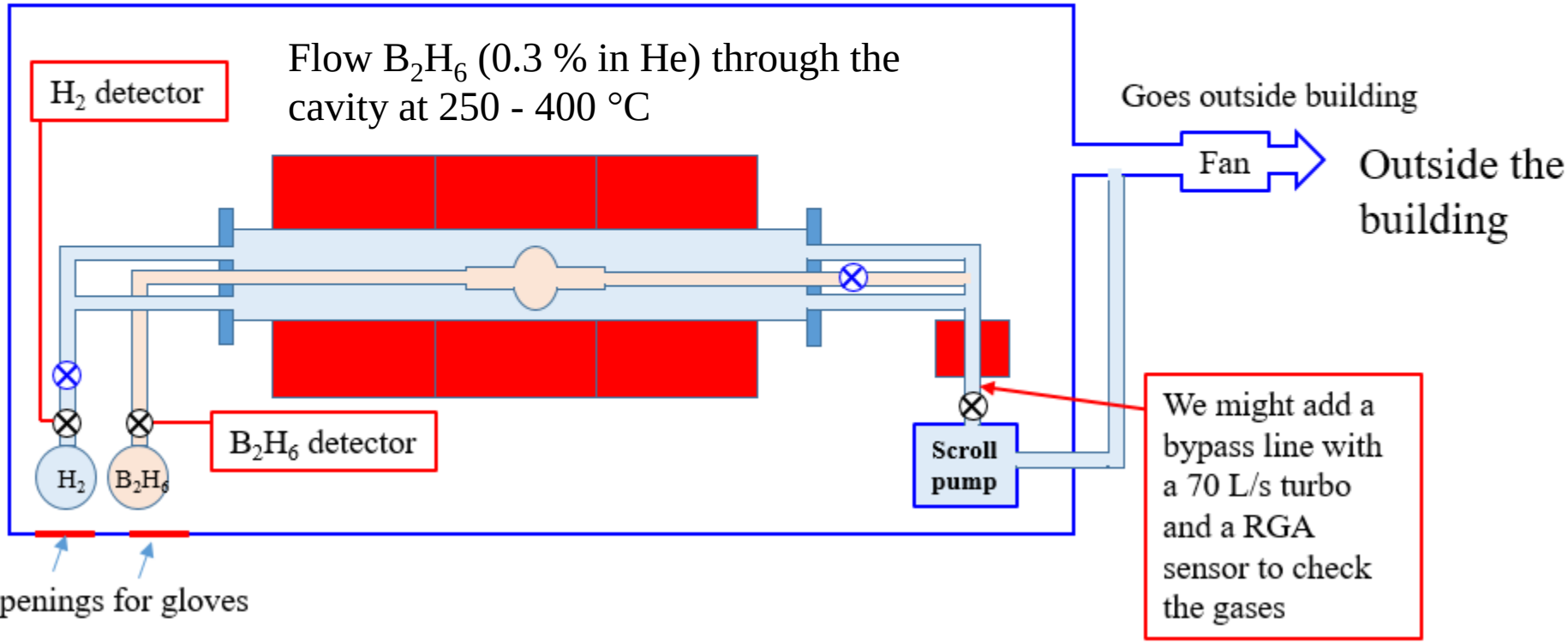
Design of new coating system (1st stage)

Heater

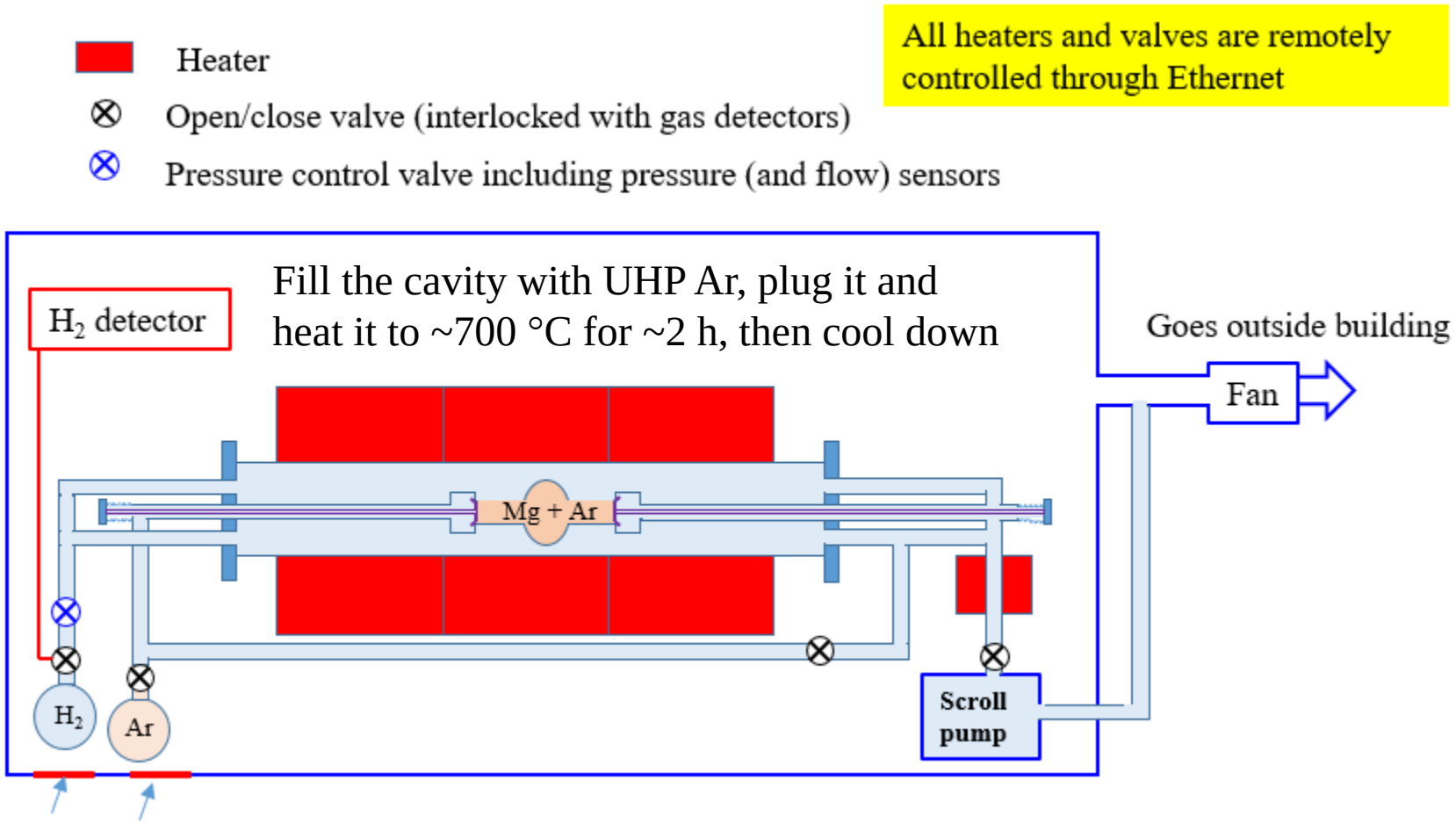
Open/close valve (interlocked with gas detectors)

Pressure control valve including pressure (and flow) sensors

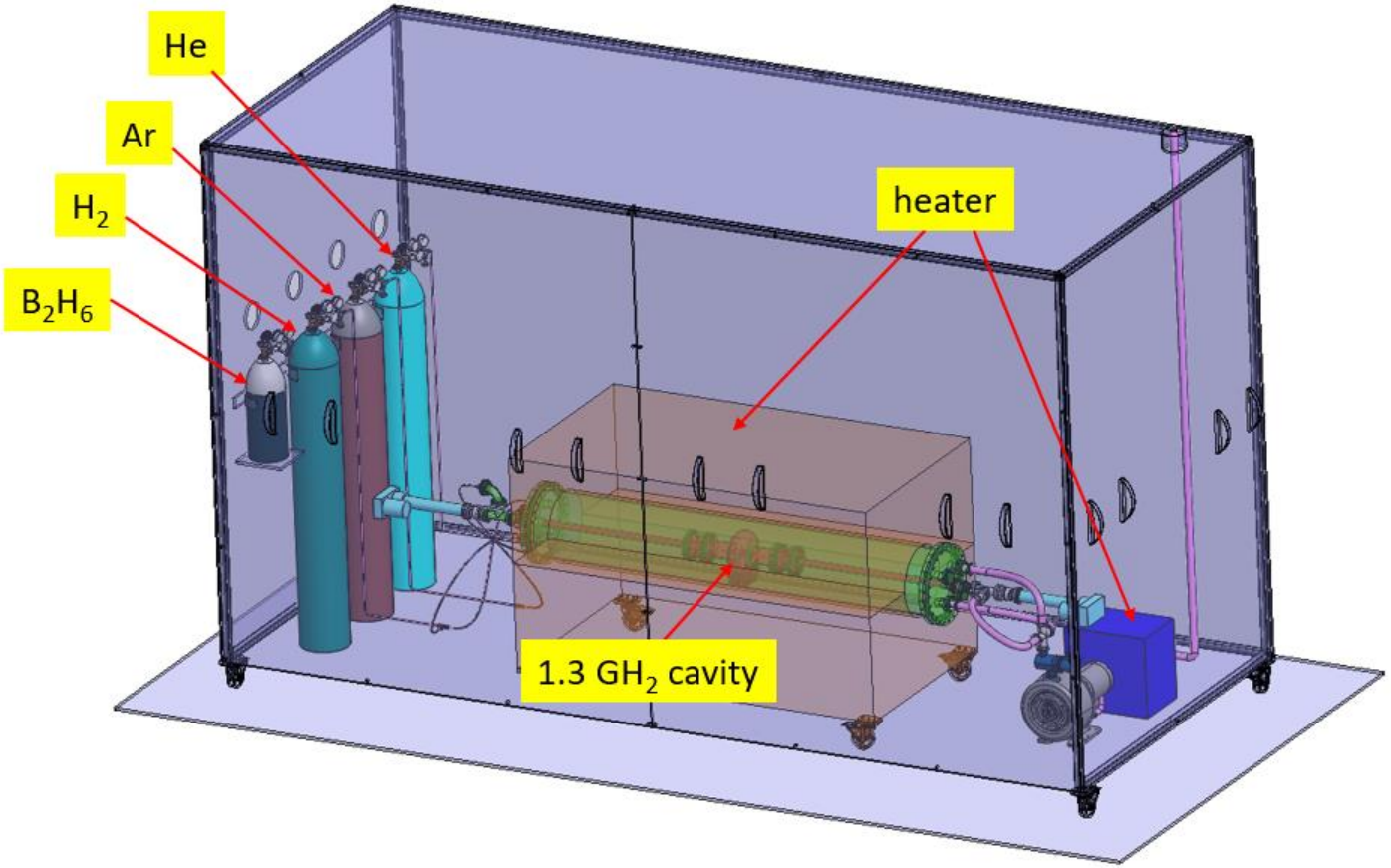
All heaters and valves are remotely controlled through Ethernet



Design of new coating system (2nd stage)

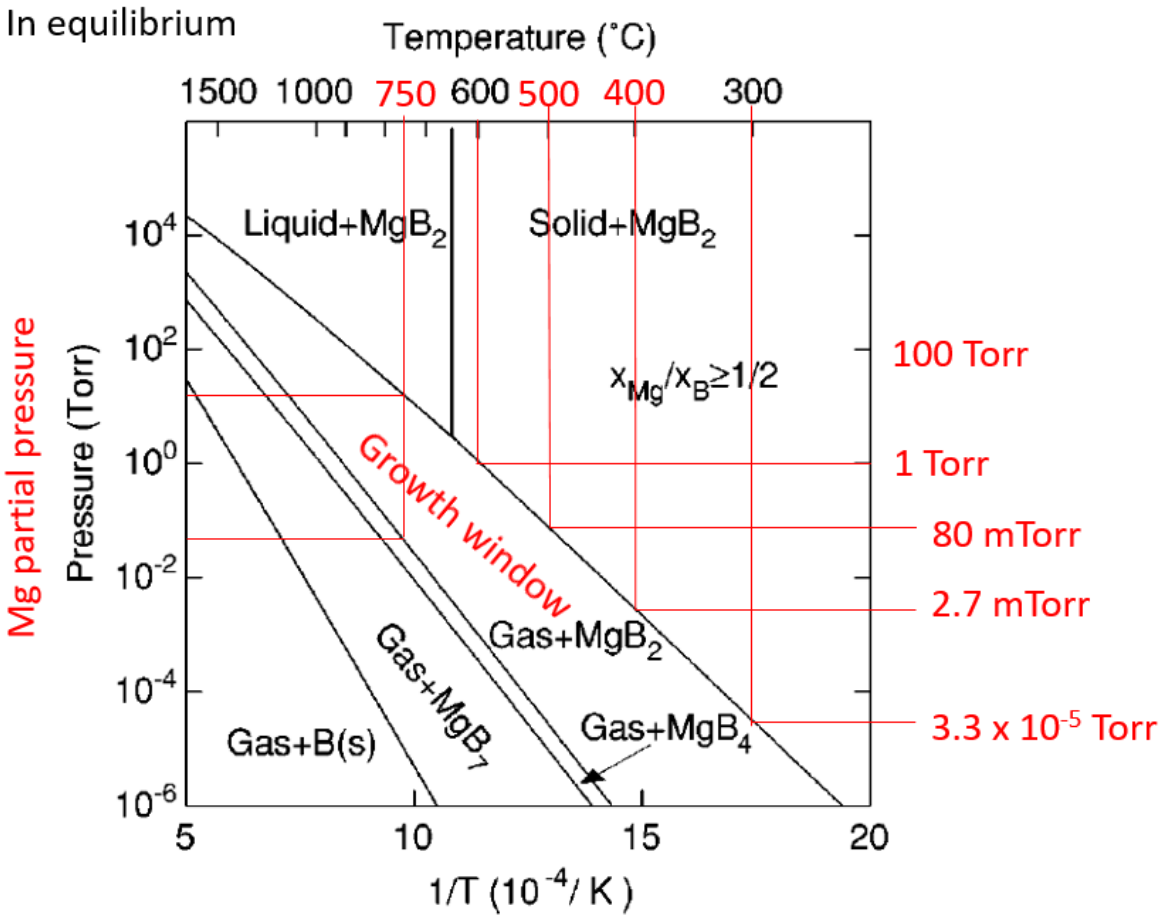


A 3D model has been constructed



Backup slides

Phase diagram



[from Liu et al., APL 78 (2001) 3678.]