Newsletter #5
July 2020

FASTGRID AT A GLANCE

Dear readers,

FASTGRID should have ended at the end of June 2020, but COVID-19 nearly completely stopped our activities which are mainly experimental at the end of the project. All the partner institutions have been closed for a while, but hopefully we will all go safely through the pandemic - this is the most important. Due to this exceptional event, FASTGRID was extended by 5 months in order to finish all the activities under progress. The project has been very rich in advances and knowledge progresses but we still need some time to finalize it.

For this fifth newsletter we focus on very innovative tapes based on sapphire substrate. They can tolerate very high electric fields, in the range of kV/m. Validated on a laboratory scale, this game-changing technology needs to be implemented on long lengths with an industrial process. The main objective of FASTGRID being to enhance the electric field under limitation, this is a highly attractive way but with a much lower TRL compared to the “conventional” one based on a metallic shunt tape, the main development of FASTGRID.

Additionally tests have just been carried out in Berlin at IPH (Institut Prüffeld für elektrische Hochleistungstechnik GmbH). We successfully tested two pancakes based on the metallic shunt tape up to 5 kV (150 V/m) several times and did some “hot spot” tests as well. All the data now has to be thoroughly analyzed.

Tests at IPH, Berlin (July 7-8, 2020)

Pascal Tixador

FASTGRID coordinator

Emerging conductors for current limitation based on sapphire substrates

One of the difficulties in the use of the existing coated conductors, based on metallic substrates, is that the maximum electrical field which can be generated during limitation is in the range of 100 V/m. For that reason, very long lengths are required in practical devices.

One of the goals of FASTGRID was to go beyond the state of the art conductors by creating a novel architecture. The main difficulty in the conventional coated conductors is that the Normal Zone Propagation Velocity (NZPV) is too low and so the heat generated during limitation can be inhomogeneoulsy distributed creating a hot spot which may eventually destroy the conductor. Sapphire has a high thermal conductivity and thermal diffusivity and if it can be used as substrate it will become a change-over strategy. FASTGRID has demonstrated that the maximum electrical field which can be generated during limitation can be increased by one order of magnitude, i.e. beyond 1000 V/m.

In the attached Figure the architecture of these emerging conductors based on $YBa_2Cu_3O_7$ (YBCO) is shown. The collaboration between Tel Aviv University (TAU, Israel), ICMAB-CSIC and Oxolutia (Barcelona) has made possible that such emerging conductors become a practical solution.

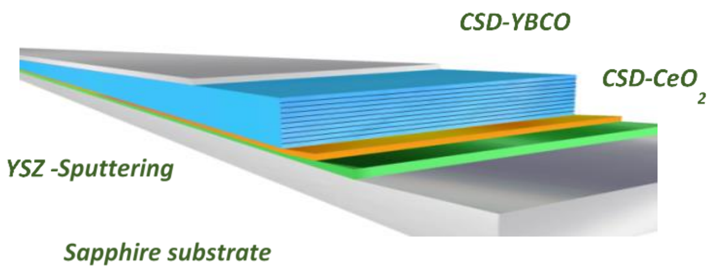


Figure 1 - Architecture for the emerging conductor based on sapphire substrates.

Figure 2 - Pictures of 1 m sapphire substrates including the YSZ buffer layer (left) and the YSZ/YBCO layers (right) grown by sputtering.

Sapphire substrates can be commercially produced at present in lengths of about 1 meter and so the three collaborating partners developed thin film growth methodologies to turn into a reality the emerging conductor architecture. TAU developed sputtering growth approaches of the buffer layer YSZ and the YBCO superconductor. On the other hand, ICMAB and Oxolutia developed the growth of the buffer layer CeO_2 and the YBCO superconductor through Chemical Solution Deposition (CSD). These two growth approaches have complementary virtues: while sputtering is easily adapted to nucleate on rough surfaces, CSD films can grow at much faster rates and so thick films with higher critical currents can be obtained.

By using sputtered YBCO films on top of sapphire/YSZ substrates with a thickness of 1 mm, TAU has demonstrated that electric fields in excess of 2000 V/m and a surface dissipation of several kW/cm^2 can be generated with any shunt, a very remarkable performance for current limitation (see Figure 3, test performed at 65 K at CNRS-Grenoble). The total critical current of the conductor, however, is limited at present to about $I_c = 50$ A due to the low YBCO thickness (150 nm) which can be achieved by sputtering.

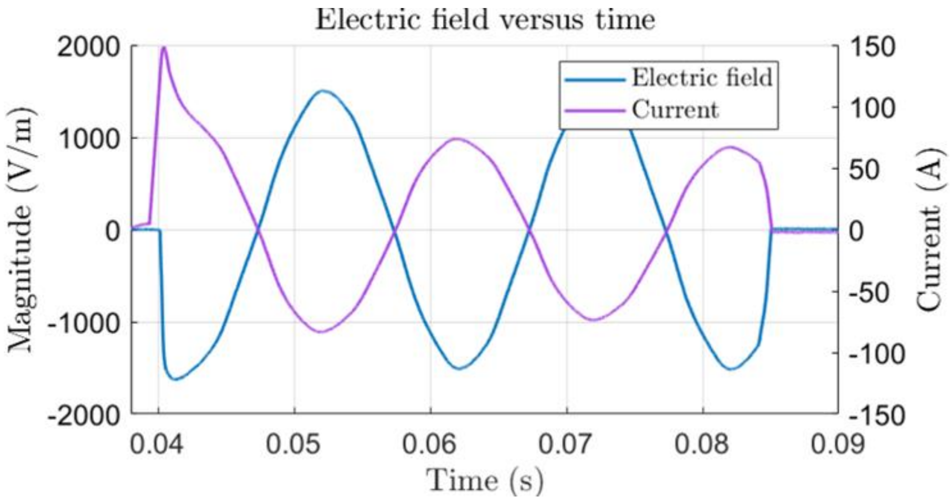


Figure 3 - Current limitation test of a YBCO/YSZ/sapphire element performed at 65 K where a high electric field (E>1.500 V/m) is generated.

ICMAB – Oxolutia, on the other hand, have completed the TAU approach by implementing the conductor architecture including CeO_2 and YBCO layers grown by CSD on top of YSZ/sapphire. CSD YBCO films with thickness in the range of 1 µm and high critical currents ($I_c = 400$ A/cm-w) have indeed been demonstrated with close performances on highly polished sapphire substrates. However, further quality improvement is still required when growth is made on the roughly polished sapphire substrates which can be prepared when lengths are in the range of 1 meter.

Figure 4 displays a 2D X-ray diffraction pattern of the full architecture of this emerging conductor, where the epitaxial quality of the three layers (YSZ, CeO_2 and YBCO) can be appreciated. The SEM image of the YBCO surface shows that a highly homogeneous microstructure has been achieved. The successful development of this novel conductor architecture, with thick YBCO films, required an extensive analysis of the YBCO oxygenation process because it is known that microcracks may develop when growth is made on top of sapphire substrates. The attractive superconducting performances ($I_c = 80$ A/cm-w at 77 K and $I_c = 150$ A/cm-w at 65 K) demonstrated with this novel approach combining sputtering and CSD film growth appears, therefore, as a novel opportunity to develop competitive Superconducting Fault Current Limiters.

In conclusion, the potential of the emerging sapphire-derived conductors for current limitation has been demonstrated, both by growing conductors in the range of 1 meter and by demonstrating very promising superconducting performances as conductors and during current limitation.

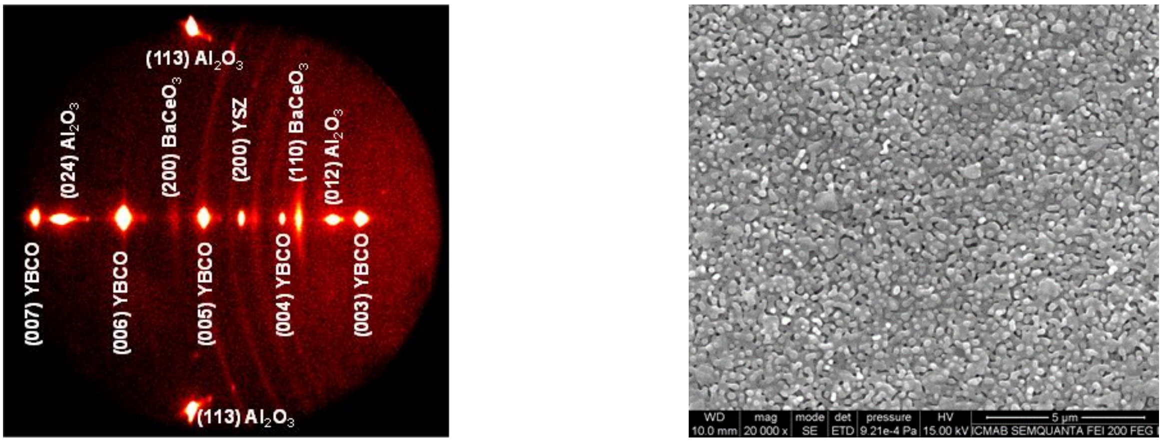


Figure 4 - 2D X-ray diffraction pattern of a 400 nm YBCO layer grown on a CZO/YSZ/sapphire substrate (left) and a representative SEM image showing a crack-free YBCO layer.

NEWS & EVENTS

7th Project Meeting at RSE, Milan

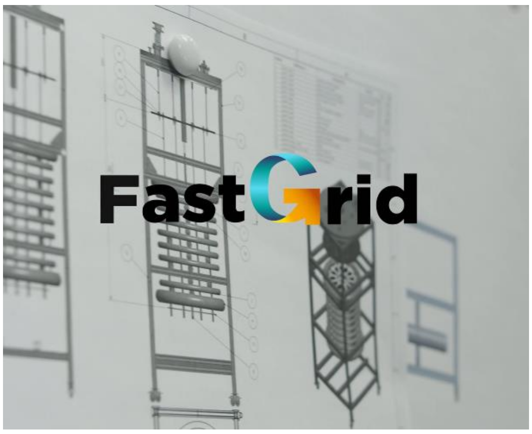
Members of the consortium at the 7th project meeting in Milan

The 7th project meeting of FASTGRID took place on January 23-24, 2020. It was organized and hosted by RSE in Milan, Italy.

As usual, the members of each work package had the opportunity to present their last results and discuss them during two parallel sessions. The event also included a tour of RSE labs and facilities. The 8th and last face-to-face project meeting will take place in Grenoble in November 2020.

FASTGRID Video

A video about the FASTGRID project was shot in the premises of our partner the SuperGrid Institute, France. The aim of the video is to explain the objectives of the project in simple terms and animations. It includes footage from the production line of our German industrial partner THEVA and from the winding process made by the French company Sigmaphi in collaboration with the SuperGrid Institute.



[WATCH IT HERE !]

Arnaud Allais joins the FASTGRID project at SGI

Arnaud Allais obtained his PhD in materials engineering (BSCCO conductors) in 2001. Since then, he has worked for the global company Nexans as a Research Engineer, Project and Laboratory Manager, then Research Center Manager. He became a member of the FASTGRID project in February 2020 when he joined the unit dedicated to cryogenics and superconductivity as a Fellow Project Director.

We wish him all the best in his new assignments!

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This newsletter has been developed within FASTGRID project. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 721019