Spotlight

Giovanni Grasso is the Business Development Manager at ASG Superconductors SpA

Superconductor Week (SW): Why don't you start by giving us an introduction.

Giovanni Grasso (GG): I've spent my whole life doing superconductivity, since my early studies in physics. This was just about when high temperature superconductivity was discovered. It was a time where there was really a lot of excitement about superconductivity. I did my PhD in materials science in superconductor manufacturing and my work and career have been based around superconductivity ever since.

For many years I was focused on developing the best possible superconductors and making HTS wires. I moved to MgB_2 when it was discovered about 20 years ago, at that time still as a researcher in a national research lab in Italy. Then I found this great opportunity to work with ASG. At the time ASG was still named Ansaldo Superconductors. ASG had a very strong traditional business in detector magnets, accelerator magnets, and fusion magnets. Many of the big large superconducting magnets had been manufactured by ASG over the past decades and this is today the strong backbone of the company. But my efforts have been to create new opportunities with this new material, MgB_2.

So I have spent about 30 years in superconductivity, most of the time in materials development. Now, for the past few years I am involved more with business development. I moved from materials science to superconducting devices, where we seek to introduce superconductivity to a community that has not yet been aware of what they could do with superconductors. It's very fascinating and, crossing my fingers, is also becoming more productive, so I'm really happy with this choice.

SW: So, you obtained your PhD in Italy or where?

GG: In Geneva, Switzerland, actually; I am from Genova and studied in Geneva; there is only one letter of difference. After my PhD, I almost decided to go to the U.S. It was the late 1990s and there were a lot of research initiatives there. But then I received an interesting opportunity to develop a new national lab in Italy, focused on applied superconductivity. So I decided to go back to my home country and study and it turned out to be a good decision. The lab is now called SPIN [SuPerconducting and other INnovative materials and devices institute]. It has several sites spread all over the country, but the headquarters are in Genoa. It's a large institute with many of activities and networks, so I was very happy with the decision to move back.

SW: Okay; ASG has three business units. You said that you started there when its name was still Ansaldo Superconductors. Was Ansaldo already focused on MgB_2 as a superconductor or did you initiate this switch?

GG: In 2001, when MgB_2 was discovered as a superconductor, I spoke about it with what was then Ansaldo Superconductors. They found the opportunity to be quite interesting. To introduce this new material, we set up a company called Columbus Superconductors. I founded Columbus together with some of the shareholders of ASG.

SW: I assumed that ASG had just acquired Columbus.

GG: Columbus became a business unit of ASG three years ago. It survived as an independent company for

▸about 15 years, 2003-2018, when it was fully acquired and incorporated into ASG.

SW: Why was it set up as an independent company initially instead of as an ASG subsidiary?

GG: At the beginning, Columbus was more of an R&D lab than a company; we decided to create it as a side project. At the same time, ASG shareholders also acquired stakes in Paramed, which at the time was a small MRI company that was just starting to be a player in the business. Paramed and Columbus were two experiments to see whether we would be able to create new businesses involving new initiatives.

SW: What was ASG's core business in 2003?

GG: ASG was 100% focused on high-energy physics and fusion research, manufacturing magnets and components. It was not involved with high temperature superconductors and or the industrial applications of superconductors. We then decided to see if we could develop a nice output of a new material for the market with Paramed. This took a few years, but we succeeded.

At some point, we determined it wasn't making any sense to keep the three entities separate. We decided to have the three companies working more closely together, with some products that would be fully vertically integrated from the wires to the magnet to the system, such as with our MRI based on MgB_2. We are very proud of how integrating the companies has increased the synergies, and the opportunities all three have.

SW: That way you have an integrated supply chain as well. So, with the Columbus unit, essentially, with MgB_2, you have a specialized manufacturing process that I've read a little bit about, called the XC2 process. How does that process work and where do you get the raw material?

GG: That is a good question. We are producing MgB_2 wires, as are a few other companies, but we are, I think, the only ones using the XC2 process, which is, I have to admit, more complex than other approaches to MgB_2.

SW: The difference is in situ versus ex situ?

GG: That is correct. Basically, the technical difference is that, in our case, we start with the magnesium and boron chemical elements. We mix them together in the appropriate ratio, which makes a powder. We then convert it already into MgB_2 before taking this powder and packing it into pipes or tubes and manufacturing a wire. The rest of the world essentially takes this mixture without reacting it, putting it directly inside the pipe or tube, making a wire and then converting this to MgB_2 only at the end of the wire manufacturing process.

This seems like a tiny difference, but, in fact, the way you process the wires is very different. We had to develop a very unique and dedicated method in order to be able to process a wire where the powder inside the wires has already reacted. MgB_2 is a very hard and abrasive material; it's almost like diamonds. It's very difficult to manufacture a wire from a material with a diamond-like hardness, so you need very specialized equipment, not what is common in the superconducting wire manufacturing industry. We had to develop our own special equipment to do this. You might ask, why go to the trouble? The answer is that the subsequent wires are much more robust from a mechanical point of view. Our wires, once they are manufactured, have a very densely packed superconductor, so they are more flexible and robust, and can be used much more easily than the ex situ ones.

Let me say something that is not so good for us: MgB_2 is not the best superconducting material. However, we think it is the best compromise. It offers good enough performance and a low enough cost to make it of interest. The big problem with high temperature superconductors is that they offer great performance, but this comes at a high price. For superconductors, what really counts is the ratio between performance and cost. If you have a very high performing material but it costs a lot of money, then the advantage may be fairly limited. In our case, we manage to create a wire that performs rather well with a low cost of manufacturing, so the ratio of performance over cost is improved compared to other solutions.

‣ Of course, this is a dynamic situation. Materials are improving; the picture of today is that MgB_2 is a viable solution for at least a number of applications and we are targeting those. This manufacturing process, XC2, is very reliable and uniform, so we can manufacture very long lengths in the range of several kilometers, up to 10 or 15 kilometer-long wires. This is very difficult with other methods or with other HTS materials, so I think this is an advantage. Of course, it's a very specific process with dedicated equipment, so it took more time to develop than expected, and more money as well.

SW: Everything involving superconductivity, everybody I have spoken to says, "Well, we thought it would take 10 years, and 30 years later here we are".

GG: Yes, but we are proud and happy because of where we are now. For instance, CERN is using a lot of cables with our MgB_2 wires and they are very satisfied. They will be powering a large part of the accelerator through our cables, with our technology, so…

SW: The Large Hadron Collider (LHC), right?

GG: Exactly.

SW: We feel that this is a breakthrough. We are going to play a big role in powering the accelerator, so there's a lot of pressure. But if CERN is using our wire it means that the technology is robust and it works. I mean, they are powering an investment of €10 billion or so through our cables.

SW: And it allows you to continue development.

GG: Right. Exactly.

SW: I want to come back to something in terms of power transmission that I've discussed with a number of other companies, I've interviewed a couple of companies that are making ReBCO tapes and doing pilot projects for things like medium voltage DC transmission. I know that there is a political push in the EU and in parts of the U.S. as well to develop pilot projects for general superconducting power transmission in the grid. The Columbus unit has developed some high voltage DC wire and it seems like you have some advantages over ReBCO. Do you have any pilot projects for power transmission?

GG: Yes, we completed a project called Best Paths [BEyond State-of-the-art Technologies for rePowering Ac corridors and multi-Terminal HVDC Systems]. This was successful; it confirmed that MgB_2 can carry electricity up to 500 times more than copper. Now we are proposing the next step, which is again for long-distance DC power transmission DC, whether it's HVDC or MVDC. We will sort this out; today, it's more of a matter of terminology. I think honestly that with superconductors we will try to push for lower voltage cables. There is no need to go to high voltage when you can carry large currents with no losses. Essentially, we will be more and more in favor of MVDC grids, cables or applications.

I agree with what you said about the political push for projects. European funding will be available soon to support the next superconducting demonstration step for this type of application. The EU will grant a kilometer-long liquid hydrogen pooled MgB_2 cable to demonstrate power transmission over long distances. I cannot say that we will be the ones who get funded because it's a public grant for European companies. But the European Union is supporting MgB_2 and other HTS solutions in general as a way to distribute renewable energies across Europe, which is going to become a dramatic issue soon. We have increasing wind energy production in the North Sea, and if we don't distribute this to distant destinations, it will result in a waste of energy and money. We need to be able to send the energy as far as possible, maybe 1000s of kilometers or more. The impact of superconducting cables is crucial. I think these cables can make long distance power transmission cheaper and easier to install, with much fewer civil works than conventional solutions, almost no environmental impact, and lower losses.

The key element is combining the superconducting cable with hydrogen, particularly in liquid form. Liquid hydrogen is cryogenic, so cooling to 20 K would be a perfect solution for any HTS or MgB_2 cable. In this way the coolant, which has always been seen as a weak point in superconducting technology, also becomes a vector for energy. After 1000 kilometers you have an output in which you have electricity through your spanning cable, let's say, chemical energy, which you can store and has many potential uses. It's a very interesting and dynamic situation right now. Europe has bet a lot on hydrogen, so there is a great deal of funding. If

▸ we are able to push liquid hydrogen as a solution to store and distribute hydrogen over long distances, and show off the advantage of combining it with superconductivity, we think we have good chance to win and to become the solution of choice. That would be really great for all applications.

SW: Besides power transmission with the Columbus MgB_2 unit, what can you tell us about the SEA-TITAN project?

GG: Europe is hungry for renewable energy, particularly in the southern European countries that have access to renewable energy sources. The more we are can diversify the sources of renewable energy, the more we can be relatively sure to guarantee an average level of renewable power to a country, whether it's coming from the sun or the waves or other sources.

For us, SEA-TITAN is a first step for studying how superconductivity can impact energy production from waves. At this stage, we are conducting a feasibility study to show this advantage and drive the development of future wave energy generators towards superconductivity. Through a design study, we have already been able to show the advantages of applied superconductivity. SEA-TITAN is actually somewhat of an old project that was submitted several years ago, but at that time we had not yet decided to make a system for this type of application. I'm sure that following good results from the project, there will be a follow up in which we are also going to use superconductivity.

SW: It sounds like the core business of the Columbus unit is the wire that's made for the accelerator and things like that.

GG: That was a good start for us. The work with CERN has helped us grow into a mature company producing hundreds, even more than a thousand kilometers of wire in a very short time. We learned a lot from scaling up to large production and we now think we can go to the next step. The idea that we are following up on is the application of this cable technology to all possible solutions that are not necessarily in accelerators. We are in discussions with companies having very energy intensive processes requiring a high flow of electrical current. They now face large current losses because they are using copper or aluminum. We are working with them to develop the most appropriate superconducting cable solutions to reduce losses, to become greener, let's say.

SW: And to be more space efficient as well.

GG: Exactly. There are incentives now for companies to reduce their Co_2 emissions. If they don't have efficient processes or have Co_2 intensive processes, we can give them superconductor solutions that are more efficient at a cost not necessarily higher than conventional solutions. This is a very good selling point with MgB_2: we are not always more expensive than conventional solutions these days and already in some cases are cheaper.

SW: I've heard from other wire manufacturers that it isn't enough to achieve parity with existing power transmission solutions, you need to have something that is more attractive in some way, otherwise you will never get utilities or other businesses to implement it because it is such a big change.

GG: Yes; when we talk to customers, their main worry is not about superconductivity. The main concern is always about cryogenics, what happens if the cooling system has a failure. People are not worried that our superconducting cables for some reason don't superconduct, they are only worried about what happens if the cooling system breaks down and about the maintenance cycles for the cooling system. In most cases the concerns are not about cable performance.

I usually give them an example: when you are undergoing an MRI scan, you are 2 inches or 4-5 centimeters away from liquid helium, but are you aware of that? Does that make you scared?

SW: I don't think most people who enter an MRI have any idea how they work.

GG: Right; so, I am telling people, when you do an MRI scan, are you concerned about the cryogenics? No; no one notices that it is a cold system. This should be the same for all other applications. We must develop and demonstrate systems that are robust enough so that people forget at some point that the system is cold. It's as if you have water-cooled copper pipes that break down; the system is not working, but you are not always worrying about the system

‣ breaking down. With superconductors it's the same; you have a cooling system and you deal with it.

And we are starting with projects and solutions where we are more than at parity; from the beginning we are offering an advantage. We need to get customers to agree to try this technology in a few places, and then use these as references for the next customers. I think we have convincing arguments today for the technology. We don't need to improve the wires and become cheaper.

SW: This is a good opportunity for me to segue over to your Paramed business unit, since you just mentioned MRI. First of all, you've been making a series of MRIs, but the biggest deal lately is the MROpen system. Are you the only manufacturer of MgB_2 MRI machines?

GG: Well, there have been a couple of prototypes. One was out of MIT using Hyper Tech Research wires, but it was a publicly funded project. I recently heard about an MRI made by Hitachi in Japan; again, it was publicly funded. I think today we are the only ones with a commercial MgB_2 MRI, although maybe some others have ongoing development projects. And there are also no HTS MRI machines.

SW: If I'm running a hospital and want to buy one, I have to come to you.

GG: Exactly.

SW: How do your MRI machines compete with LTS machines?

GG: It's a good question. At the beginning, we tried to diversify our design and solution, instead of replicating a niobium MRI system, which are typically tube-like closed systems or, more rarely, open but C-shaped. We designed a very challenging U-shaped MRI, which is wide open and very comfortable for the patient. Of course, this comes at a cost in terms of performance, because the U-shaped magnet is probably the least effective for producing a high magnetic field. The tubular shape where the patient is in the center of tube is the most efficient solution for creating a strong magnetic field. With the C-shaped system, people generally have to be thinner rather than wider to fit, so it's not for everybody. I'm more cube-shaped so it doesn't work for me. The C-shaped machines have a small gap, so magnetic field production is quite efficient.

With the U-shape you need the largest gap, so you have to create the field in greater volume. It's a less efficient way to create a field, but we decided to go for a solution that gives more advantage to the patient although creating more difficulty for the engineers due to the magnet design. It turned out to be a very interesting solution; this has such a flexible magnet design that you could use it for a lot of dedicated applications. It has opened up many possibilities, such as doing a stand-up MRI or an MRI on people feeling pain while they are in specific positions. We are still analyzing what our customers to date are doing with the system, trying to see whether we should still consider this as a generic, general purpose MRI system doing all types of scans or analysis, or should we focus on some specific applications that are enabled by this open design.

SW: The Paramed unit previously produced other MRI machines. What was the chicken and what was the egg in terms of this magnet shape for the MROpen machine? How did this idea come about?

GG: Paramed had an earlier machine that was open but C-shaped but there was an increasing effort, mostly from Asia, to commercialize C-shaped systems. So, in order to innovate, diversify our peoduct, and have an advantage over this wave of lower cost magnets and systems coming from China, Paramed decided to do the opening differently. This was a good decision because today we are still the only company making U-shaped superconducting MRI systems. On the other hand, the MRI business is populated by monsters, like Philips, Siemens, and GE. These are huge companies with large budgets and extensive markets selling thousands of systems a year. We are a small division of a few tens of people doing our own MRI systems from MgB_2 to the imaging system, all the steps from working with the chemicals to the manufacturing.

SW: Yeah you have a vertically integrated process.

GG: It's impressive, but it's also challenging. We feel positive because we see that our customers are more and more using our systems for specific types of analysis, so we are learning from them about the

▸ benefits of having this system.

SW: What is the most profitable unit of ASG? Is it Paramed or Columbus or…?

GG: Today, it's still the older ASG unit because it has a strong backlog of orders for the production of magnets. We think that Paramed has strong potential; we are also supplying our MRI systems as a real-time imaging system for proton therapy cancer treatment. This is a process that, combined with cancer treatment beam lines, helps doctors to focus the beam on the right place where the tumor is located. With our open MRI system, this can be done in real time. It allows the beam to go through the magnet and the opening, and hit the patient while at the same time producing an image; we think this is a very clear advantage. We have had a few cases in Canada and now in Germany where we are supplying the system; it's a new MRI application and we think it will grow significantly.

SW: This is a good time to ask you a few questions about the magnet unit since we are on the subject. I noticed, based on recent projects, that it seems like your biggest customer over the past few years has been the ITER project. You are producing two different types of magnets. You are doing the toroidal field coils and the poloidal magnets. Are these NbTi or Nb_3Sn?

GG: The toroidal coils we produce are Nb_3Sn. These are the most challenging magnets, since they need to be baked and, considering the size, are huge coils. They have to be heat treated for a month or so at 600+ degrees.

SW: How do you heat treat something that large? Do you have ovens that big?

GG: Yes, we have a huge furnace that is larger than this. It's a huge pizza-like furnace.

SW: An electric-powered furnace I would assume.

GG: Yes, but the treatment is done in an oxygen-free atmosphere. It's not easy because you don't want it to oxidize. There are other challenges to working with such a large coil. if you put it in high temperature you have thermal expansions and the like. Anyway, the toroidal coils are Nb_3Sn while the poloidal coils are NbTi because they are at lower field, but they are so large that we are actually building them onsite. We have a dedicated team of about 30 or so ASG employees who are doing the manufacturing at the ITER site in France because those coils are so large they cannot be transported. While ITER is our main customer, ASG has a number of other interesting projects as well.

SW: Tell me a little bit more about the furnace that creates one of these pancake coils. What does the cycle time look like for the baking: does this happen before or after laser welding? When was the oven installed?

GG: We bought the furnace especially for this job, because the requirements called for such a huge furnace. Actually, we used another furnace to make the first ITER demo coils for the early studies of ITER around 20 years ago. The furnaces for ITER are always custom-made.

SW: So you design it and then commissioned a company to manufacture it?

GG: Yes. It's crucial to have a specific, very uniform temperature profile and heating ramps, cooling ramps, oxygen, atmosphere, and so on for what is a very complex work. You can imagine: you shape a massive cable into a D-shape, you double pancake it, and you bake it in the furnace. You typically manufacture the cable in an unreactive state because, once you bake the niobium conductor, it becomes very brittle. You pull the cable out and you very gently open the double pancake in a way so that you can insert the plate in-between. It is like opening a spring and placing some steel plates in the middle and closing the spring. It's a very difficult procedure, but we have now completed the production on the last one. The last TF coils will ship in September.

SW: So how many in total did you produce?

GG: Ten, but each coil is double pancaked.

SW: How many pancakes have you broken after baking? It's quite a brittle material.

GG: I think we are not allowed to break any, because they are so expensive. You have to be very careful. I think we announced recently that we received the

‣ order from DTT (Divertor Tokamak Test facility) for toroidal field coils, so the idea is to continue using our facilities to manufacture these. DDT is a national fusion project in Italy. This is a small tokamak in size compared to ITER, although not that small at the end of the day. It will conduct some demonstrations for ITER. We have to manufacture a set of toroidal coils smaller in size than for ITER but still quite big. The plan is to reuse some of the equipment we already have. This will give us some continuity; even after we ship the last coil to ITER we will continue the nuclear fusion effort with this equipment.

SW: Do you have any other recent developments that you want to tell us about?

GG: We just signed recently an MOU with Chubu University (see *Superconductor Week*, Vol 35, No 6). Chubu is driving a significant effort in HTS transmission cables; they have HTS cables powering their own data center. They have a strategy to create real standards for superconducting cables, and to develop a future 100-kilometer transmission line connecting two existing electricity lines. They have an aggressive approach but are very practical with an industrial frame of mind, although being a university. We hope that this MOU expands opportunities of mutual interest and enable us to have a part of what is happening in Japan in the future.

SW: It's very important to get standards established for cables if you want utilities to adopt them nationally or across some union like the EU. You have to have standards or else it's not going to get adopted.

GG: Exactly. Although it can be boring to create standards, it's essential. This may be the most important piece of paper that we are working from.

SW: My next question is more about the company as a whole. You guys are a fairly big player in a lot of these areas and I would imagine that it is sometimes difficult to source from just the local labor pool. Is your staff mostly Italian, or do you have people for other countries that come to work for ASG. It seems like you could attract a lot of foreign talent because you are making this very high tech products.

GG: Many of our employees have come from abroad, although they are Italians. Many Italians have studied superconductivity, fusion, materials science, and then left Italy to study or work in places like Illinois or Japan. So the easiest choice for us is to attract back some of the Italians who have spent many years in research institutions or industries abroad. This works well, but of course we are also hiring people from other countries. I have a very good French colleague working with me now on the transmission cables, who travels back and forth between France and Italy every week. We have a number of open positions, maybe ten or fifteen, for engineers, cryogenic engineers, magnet designers and so forth.

Our expansion means that we believe a lot in superconductivity. We need a new generation of people, because ASG started a number of years ago, so the first generation is retiring and also the business is changing. We don't want to abandon our strong position in energy and fusion while we seek to grow in energy-related businesses and applications. We see a lot of opportunity, and hope that this will attract more people and projects.

It's not anymore a question as to whether superconductivity will be used one day. I think it is more about when it will be used. It took a little time, but I think people in the energy sector now understand what we can bring to the table.

SW: Well said; thank you so much for your time.. ■