Research Interests – Dr. Baptiste Jean Germain Gault

Materials are everywhere in our daily life, so much that we stop thinking about them as being complex architectures made of atoms. This is particularly true for metals and alloys that humankind have been using for thousands of years. This might be the steel in the rails on which the train is that takes you to work in the morning, the aluminium alloy that makes the casing of your mobile phone, or the nickel-alloy in the turbines that propel planes across the oceans. All these materials draw their physical properties from the way atoms of different elements are arranged inside the material. This is where the work of Dr. Baptiste Gault finds its importance: he studies materials at a resolution reaching down to single atoms to better understand how these control the material's properties.

For decades, there were no suitable techniques to visualise and quantify elements at the right scale: less than a nanometre. To provide some perspective, a nanometre is 100000 smaller than a human hair. Since his doctoral work, Dr. Gault has contributed to making possible to measure the nature and position of each individual atom in a small piece of the materials by further developing a microscopy technique called atom probe tomography. Dr. Gault made his key breakthroughs by connecting disciplines: ultrafast laser and high electric field physics, big data and machine learning, materials science & engineering, with a recent interest in bridging towards biology.

How does the blade of a turbine in a plane deform when it is held under high pressure above 1000 degrees? Understanding this is critical to avoid catastrophic failure, and this involves subtle interactions between defects created inside the structure of the material and atoms of different elements that constitute the material. Dr. Gault's work focuses on measuring these changes at the atomic-scale. This information has now become crucial to understand the behaviour of materials in particular during service. This knowledge is then used to optimise the design of materials and provide them better properties, for instance make a much stronger steel, or have a longer lifetime in service, for example in a steam power station. He has applied his expertise in atomic-scale characterisation to materials, which find key applications in such diverse fields as energy conversion, for instance solar cells or thermoelectrics, catalysis for water splitting, but also for structural, load-bearing parts like steel or aluminium alloys found in planes or cars, and more recently magnets for electric vehicles or windmills. His focus was constantly on explaining the fundamental aspects of materials science.

Supported by the European Research Council, he is pushing the limits of microscopy and microanalysis to study the distribution of hydrogen atoms in complex alloys. Hydrogen is the lightest element, it is extremely mobile but has been known to accumulate inside most metallic materials and render them very brittle. This has been known to lead to pipeline breaking and subsequent oil spill or the failure of bolts of the San Francisco Bay Bridge. This problem, known for well over 100 years, remains unsolved because no one could measure precisely where the hydrogen was inside of the materials in three dimensions. Gault's group is currently working on this frontier in materials like steel and aluminium, but also in materials that can be used to contribute to sustainable hydrogen generation and storage.

There are two final frontiers that Gault's group is currently pushing. First, his group recently initiated a new activity to revive a precursor technique to atom probe, field ion microscopy, which offers an even higher atomic precision, in conjunction with big data techniques, to provide even more detailed views on the nature of individual atoms and the surrounding crystal. These efforts may lead to what might be the ultimate microscope. Second, Gault's group initiated the use of atom probe for medical applications. It is now possible to map protein fibrils that are relevant to the Alzheimer disease, three dimensionally, but more needs to be done to establish the full potential of the technique.

Over the course of his career, Dr. Gault worked in France, Australia, the UK and Canada. Since 2016, he leads the research group "Atom Probe Tomography" at the Max-Planck-Institut für Eisenforschung GmbH in Düsseldorf. Dr. Gault has a strong network of collaborators in particular at Oxford University, The University of Sydney, the Grenoble Institute of Technology, the Indian Institute of Science and more recently at Imperial College London, where he holds a part-time position as "Reader in Materials".