



Erlangen-Nuremberg Non-technical Report

Graham Kimbell

Bavaria – a land of beer, pork, and more beer. This is my second summer placement through the CaMPUS scheme, and this year I was working at the Friedrich-Alexander University Erlangen-Nürnberg, in the heart of Bavaria.

Erlangen is a large town outside of Nuremberg, which is mostly dominated by the university, as well as Fraunhofer Society and Max Plank research institutes, and Siemens offices. In many ways, it is like a Bavarian Cambridge, with a historic centre, large student population, and countless cyclists. The lab itself is based at the outskirts of town, a 10-15 minute cycle from the centre, protruding into the adjacent forest.

My last summer placement was in French-speaking Lausanne, Switzerland. At the time I was apprehensive about only having a GCSE in French, but I found that the language quickly came back to me. This placement, however, was another beast entirely – to put things in perspective, before this summer, I couldn't count past 3 in German. Fortunately, the German population is far better at languages than me, and nearly everyone can hold a conversation in English. This is not to say I didn't get to practise my German – I can now confidently count all the way to 10, and members of the lab have taught me all of the essential phrases, such as: "Servus" (Chao), "Ein Bier bitte" (A beer please), "Prost" (Cheers) and "Wo ist die Oberbürgermeister? Ich muss mit ihm sprechen, den ich habe wichtig Geschäft" (Where is the mayor? I must speak with them, for I have important business).

Members of the lab ranged from students completing their Bachelor's theses, to other placement students, PhDs, post-docs and professors. Whilst most were German, there were also students from France, Turkey, India and China, among others. Luckily for me, English is the common language of the lab, and groups would often flawlessly transition their conversations into English if I or other foreign students joined in.

For work, part of me expected the stereotype of German efficiency: arrive 0900 hours, work diligently, half hour lunch, more industrious work, leave 1700 hours. In reality the atmosphere in the lab, as with many other universities, is very relaxed. This is not to say the students didn't work hard – my supervisor in particular would arrive at 7am almost every day to get extra work done before the labs got busy, a concept that seems borderline-masochistic to me. Nonetheless, the flexibility of hours and personal responsibility given to the students makes the lab a more enjoyable place to work.

Outside of working, Bavaria is a very beautiful and interesting place to explore. The nearby city of



The medieval centre of Nuremberg. Despite the city being almost entirely destroyed in WW2, the city centre has been rebuilt faithful to its original style.



Taking a ride down the Eisbach in Munich, with surfers waiting to ride the artificial waves.

Nuremberg has a rich and dark history: it is home to the Nazi Party Rally Grounds, the Nuremberg Trials and a medieval city centre. Other towns nearby frequently host music, beer and street festivals, and cities like Munich are close enough for a weekend away.

My work was based on the high temperature stability of coated cobalt-based superalloys. Since the 1940s, nickel-based superalloys have been the state-of-the-art material for demanding high-temperature applications such as jet engine turbine blades. Their high temperature strength is owed to a specific microstructure – the γ/γ' structure. In 2006, a similar structure was found in the Co-Al-W system. Alloys based on this system have good strength and creep resistance, excellent castability and melting points 100-150 K higher than commercial nickel-based superalloys, so could potentially supersede nickel-based superalloys as the material of choice for demanding high temperature applications. This depends on whether the γ/γ' microstructure can be stabilised at higher temperatures, and the oxidation resistance or compatibility with protective coatings is improved.

My project involved studying the compatibility of Ni and Co based bondcoats on a particular Co-based superalloy. The two types of coated samples had been oxidised in air at 1044 °C for up to 1000 hours, and I used optical microscopy, SEM, EDX, EBSD, and nanoindentation to characterise the coatings before and after oxidation. With this information I could compare the effectiveness and the differences between the two types of coatings. It was rewarding to see the process from sample preparation, to measurement, to results and analysis, and it was exciting working in a new and developing field. I found that the cobalt overlay coating had a more protective oxide layer, but the bondcoat microstructure dissolved more quickly. After 500 hours detrimental brittle phases formed throughout the bulk in both samples – a process which I thought showed the thermodynamic instability of the superalloy at 1044 °C. However, my supervisor pointed out that the defects could simply be from the initial casting, and without another 1000 hours spare to check, there was no way of knowing! I had to simply add a disclaimer to my work: “please note all this speculation could be wrong and it could just be a casting defect”. The institute said they will be continuing with this work and I hope to stay in contact with them to find out what is really happening in this alloy.



Funded placements in European universities are a fantastic opportunity: these placements give you real research experience, look great on a CV, and let you travel and meet new people on a budget. On top of all this, the Materials department and other universities do so much of the organisation that the application process is very simple and painless. To any Materials Science students reading these reports, I urge you to apply!

I'd like to thank everyone involved in organising the placements from the Cambridge Materials Department, and Erlangen University General Material Properties Institute, Markus Kolb and Steffen Neumeier for their patience and support during the placement, and the financial support of Erlangen University and the Worshipful Company of Armourers and Braisiers, without whom the placement would not have been possible.

To finish, I leave you with a snippet of conversation I had with another student.

“Here, it's fine to drink beer before 12 or after 4.”

“But we're drinking beer now and it's 2.”

“Yeah, but this is with lunch, so it's fine.”