**Science in Partnership Podcast**

**Episode 1 – Andy Humphris**

A podcast from the Science Partnership Office (SPO) at the University of Bristol.

Recorded on 12 May 2021.

**Speakers:**

Emma Creasey, SPO Co-Ordinator

Dr Anne Westcott, SPO Manager

Dr Andy Humphris, Aegis Professor in the School of Physics and Chief Technology Officer at Infinitesima Ltd.

**Emma**: Hello and welcome to the Science in Partnership podcast from the University of Bristol, a podcast showcasing scientific research and celebrating its real-world impact. My name is Emma Creasey and I'm the coordinator of the University’s Science Partnership Office or SPO. Joining me today are; Dr Anne Westcott, the manager of the SPO - good morning -

**Anne**: Good morning Emma.

**Emma:** - and our guest today is Dr Andy Humphris - welcome Andy.

**Andy:** Good morning.

**Emma:** Andy has a two in one role as he's both an academic and an industry professional, being the Aegis Visiting Professor based in our School of Physics, and he's the Chief Technical Officer at Infinitesima, a company that manufactures scanning probe microscopes. Andy founded Infinitesima in 2001 as a spin out from his research at the University. It's developed a new fast surface measurement technique, the rapid probe microscope, which Andy will tell us a bit more about later.

But first Anne, can I ask you to say a few words about the Science Partnership Office and why we exist, and also a bit about what is the post of Aegis Professor and why we created that.

**Anne:** yeah thanks Emma and so the Science Partnership Office, or the SPO as we’ll probably keep referring to it, really set up at the Faculty level in the Faculty of Science and our whole purpose is to foster and generate links with industry, links with business and with government and the third sector, as well, and as part of that we have set up the Aegis Professor scheme. And Andy it's great to be talking to you today, you are our first visiting professor in this role.

What is an Aegis Professor? Well, it means somebody that will support and help us really, what we're really looking for is that that voice and that view of how science is being used in the real world at the moment and industry, Andy really does that.

**Emma:** Thanks Anne. Andy, it's great to have you with us today, before we start talking about Infinitesima and scanning probe microscopes, let's hear a bit about yourself and how you got here in the first place. So the Aegis professorship here in the physics department is actually where you yourself studied, so did you have an early interest in physics?

**Andy:** Well, first I’d just like to say how delighted I am to be here and how honoured I was to be able to accept this position and have the chance to talk to you today. So I guess my initial kind of memories of what I wanted to do growing up was actually more engineering focused, I’d always been interested in how things work, and you know very guided by my father, who was an engineer. And really felt that was the path that I was going to take, it was only really later on when I was making some final decisions about where to study and what to study that I made a decision to move to a more fundamental path and take a scientific route, and that's when I chose to study physics.

**Emma**: I suppose, physics is engineering at the very basic level isn't it, how things are put together.

**Andy**: Well indeed so I think you know, as we go through this discussion today, hopefully it will come out how I think that I very much sit on the borderline between engineering and physics and that's really served me very well.

**Emma**: Yes, we'll talk about crossing between subjects which is really important to us in in the SPO. What was it about Bristol that brought you here?

**Andy:** First and foremost, Bristol's an internationally recognized university with an outstanding physics department, and that was the primary reason for wanting to come to Bristol. But then when I visited Bristol, I remember it being very inclusive in a very supportive environment. And you know it's also a beautiful city, so it became quite an easy decision that Bristol was the place that I'd like to come and study. I guess what I didn't realize at that time, when I made that original decision to come to Bristol, that I might be staying in Bristol for such a long period of time, and because obviously I did my first degree at Bristol but then during that time, also through - really through internationally recognized research, decided to stay as part of the microscopy group and that really sort of laid the foundation for the path I ended up taking with my career.

**Emma:** So what was the microscopy group, what were they doing at the time?

**Andy:** So, to the microscopy group, it's actually a group led by Professor Mervyn Miles. And they had a new type of microscopy or relatively new type of microscopy called scanning probe microscopy and what really drew me to it was the interdisciplinary nature of the activities of the group so when I came to the end of my physics PhD I really wanted to - didn't want to carry on purely in physics, but I definitely wanted to stay in research and so I was really looking for something that was interdisciplinary. And the research group were looking at biological systems, so using this new form of microscopy to look at biological systems and that's what really drew me in and grabbed my interest.

**Emma:** see we don't normally associate physics with biology, ‘cos physics can seem a very hard, dry subject with all the hard maths, and biology is the squidgy stuff. So how do those two come together?

**Andy**: yeah excellent question, so it's because of the way these microscopes work, they're actually very well suited to looking at biological systems, and there was the opportunity to work with the Long Ashton Research Station that's just outside Bristol. But they were looking at, at that time, gluten proteins and using these microscopes to understand how the gluten protein functions which actually is very relevant to lots of people who have intolerance.

**Emma:** And was that where you did your PhD, in that research centre, as well?

**Andy**: So I was based at the University, but had strong links with the Long Ashton Research Station.

**Emma:** So what is it about scanning probe microscopy which is good for looking at biological samples, that where maybe another microscope wouldn't be able to do that?

**Andy:** So these scanning probe microscopes work in a slightly different way to what we imagine being, you know, a conventional microscope.

**Emma**: yeah, I think say the word ‘microscope’, people are thinking of that thing with three lenses sticking out the bottom sitting on their school lab bench - that's not what you're using is it.

**Andy**: Very, very different! But it's called a microscope because it produces images, but apart from that, how they work is very, very different and actually, people always use the analogy to a record player so they're a form of mechanical microscope is how I think about it, you have a very sharp tip that you bring down onto your surface and you measure the interaction between that tip and surface, you know, the force - just like using your finger if you're feeling a surface, and then you move that tip backwards and forwards across the surface, which allows you to build up an image of that surface.

**Emma**: OK, so the tip is reading the surface and making a picture of it, but at a really, really tiny level. How tiny are we talking, this level?

**Andy:** Well, I mean, the thing that's rather remarkable about these microscopes is that you can image or you can sense things all the way down to the atomic scale so to you know, try and put that in context, if you if you take a human hair, for instance, which is point one millimetres or what we would say as 100 microns across, but if you were to slice that hair into 1000 pieces and then take each of those pieces and slice that piece into 1000 pieces -

**Anne:** Wow!

**Andy: -** then you would then be down at the lengths of interest or the lengths that these microscopes can resolve at.

And coming back to your original question, why are these so well suited to biological systems? Well, unlike, first of all, optical microscopes can't offer this resolution. And you need to use electron based microscopes, but electron based microscopes need to operate in a vacuum environment and so for biological systems, obviously the vacuum environment is not very appealing. Because these microscopes operate in this different way, you can actually operate in liquid environments or air environments, so you can look at biological systems in their more native states.

**Emma**: It is fascinating, so you can actually look at a living sample?

**Andy:** Absolutely, and a lot of, you know, a lot of work has been done in that area and some of my original work was to look in that direction. And some of the challenges that I ended up addressing during my PhD was targeted at that, and so you know I've kind of sung the praises of these microscopes but one of the disadvantages of these microscopes is they're relatively slow. So, unlike an optical microscope or indeed an electron microscope, where you can, you know we're quite - normal - quite used to seeing video images. And, whereas these microscopes, because they have to kind of mechanically sense the surface and build up an image line by line, that means that they're, you know relatively slow, and so, although they can look at living biological systems and the rate at which they can look at those systems - it has been limited, and that was one of the areas of my work during my - actually slightly after my PhD but while at Bristol. It actually is an area that has been, you know - these microscopes can do an amazing job, through a lot of research.

**Anne:** Do you think Andy there will be developments where these types of microscopes will perhaps get faster and be able to do that? I know you're working with semiconductors aren’t you, but it clearly is room for expansion there.

**Emma:** Well we’ve started talking about semiconductor structures, could you explain a bit about that and just briefly explain semiconductors and what it is in your work that you have to do with them.

**Andy:** Yeah so semiconductor devices, I mean we all, we all know that we're craving for more and more capability in our phones and our desktop devices, and I think that people are sort of aware of the history of the semiconductor market of this, you know, very famous Moore's law, so very famously the ever sort of increasing performance of semiconductor devices which, you know, traditionally has been linked to making the semiconductor devices or the transistors smaller and smaller and you know that's really the focus of Moore's law. But very much more recently the devices, as they need to shrink further have become three dimensional in nature and that's really where the techniques such as scanning probe microscopy fit, because not only does it develop an image of the surface, but it actually develops a height map of the surface, so one of the capabilities of these microscopes is they can measure three dimensional structures.

**Emma:** Before, was it a 2D process that people were using?

**Andy**: Yeah, so the transistors used to be very much plainer in nature. But then to increase, to continue the scaling, as people say to continue the reduction in the size of the devices, they needed to go from a plainer two dimensional structure to a three dimensional structure, and that meant that metrology techniques, you know, are now required in order to measure the heights of the structures or the depth of the features that are being manufactured, and that's really the opportunity that's been created for Infinitesima’s technology.

**Emma:** How did you get on to founding Infinitesima in the first place? So presumably you found that there was this niche in the market. Did you do work yourself on improving the microscopy techniques to start with?

**Andy:** Infinitesima started because of a sort of a sequence of events and so during my PhD, and also the research group at Bristol, we were developing new techniques to enhance the capabilities of these scanning probe microscopes and these techniques. And that really sort of led to us wanting, or other research groups wanting, to collaborate with us and utilize those techniques that we were producing. And one of the areas, one of the things that we had developed was effectively a box of electronics that you could connect up to the microscope and it offered certain enhancements to the capabilities of the microscope. So we found ourselves in a situation where we were making these boxes of electronics, to be shared with other research groups.

And also around that time – and I think this is, you know this has continued and has been a strong focus of universities, is to look for ways in which to exploit the developments that have been made within the university, other than just the academic exploits but also the commercial exploits - so at that time we had a lot of support from the university to look at ways to protect the developments that were being made in our research and we actually, that led to us filing a number of patents with the support of the University of Bristol.

**Anne:** Is it fair to say then that you kind of saw that you definitely had a market, because you had those internal groups who were looking towards you to provide things for them - other researchers, other groups within the university - and then you started to think about the market that might be external, as well?

**Andy:** Absolutely, so we realized that there was a market for these, for some of the developments that we were making in the research group, and that's really what led us to start a business. And at that time we didn't really know what that meant, and we actually sought external advice from -because there was actually five of us involved in starting the business, and one of the members of the team had a friend who had just been through starting up a company, and sought his advice. And as these things go, he actually ended up investing and being our first investor in the company, and that's what really started it.

**Anne:** So helpful to have that real, to have somebody who’s just had the experience of going through that.

**Andy:** Absolutely and taking advice and listening to people, I think is one of the key takeaways for me from going through this process. So that's what led to the beginning of Infinitesima, and that started us down this road, we were very small, I think we had one person that was based in the physics department and the physics department was incredibly supportive.

But then, we’d sort of started the ball rolling and were taking some investment and that meant that you had commitments to people, the person that you've employed or the people you start to employ, investors, and so we carried on down this this path and that led to us taking further investment. And actually in 2004 we’d sort of grown to a size, I think with maybe five people and we decided to leave the physics department.

We released a high speed imaging product that was still focused at scientific research and still focused at, really, biological imaging. But when we put that into the market, we then received a huge amount of interest from the semiconductor community. And they shared their kind of interest and requirements to start measuring these devices that they were fabricating. And that really led us down the direction of moving away from the research market, and as we now are, completely focused on the semiconductor market.

**Anne:** Fascinating. Would you say, would you call that serendipitous? - moving towards a semiconductor industry? - or would you call it calculated and you know, it was part of the plan. Or did you just see this extra application? You know my background’s in pharmaceuticals, and often we find that a drug developed for one thing is actually very good for something else. Serendipity is quite important sometimes, at the beginning of a business, maybe.

**Andy:** I think it's partly through, I mean, we had, you know, investors in the company, we had - and we were seeking advice on how to move the business forward, and so partly putting the product on the market was to dip your toe in and see where the interest lies. One of the challenges with the semiconductor market is it's a very large market, the equipment is very, very complicated, so we decided as a business model we would focus on our core competencies.

And we actually put our technology into a module, and we were looking for people that would then take that module and integrate it into their equipment, and then provide that to the end users. And we were really fortunate to be able to build a partnership with Zeiss, who were the first company to really work with us to take our technology into the semiconductor market.

We always felt that we could offer this nanometre resolution imaging in an atmosphere environment without having to go to vacuum, but something that we had learned very quickly is that scanning electron microscopes are incredibly capable tools, and the idea of trying to compete with an incumbent technology that’s so versatile was not going to be a successful route. And so, what we found is that our technology can also work in vacuum, so actually we developed the technology to work in vacuum alongside a scanning electron microscope and the opportunity with Zeiss was looking at the photo masks.

So when you make a semiconductor device it's… you use optical lithography to actually print the devices on to the wafers, and that means you need a negative or a photomask and the product that Zeiss were producing was about this photomask, manufacturing these photomasks. But in the semiconductor market, everything has become so complicated and so small that you can't fabricate one of these photomasks perfectly. You do your best to produce one, and then you have to repair them And so we, or our technology was incorporated into a product produced by Zeiss called their Merit Next tool which is a tool that repairs photomasks. They actually use a scanning electron microscope to do the repairs, so our module sits alongside their scanning electron microscope and provides height information that the scanning electron microscope can't provide. So it provides complementary information and assists in the ability to repair these photomasks.

**Emma:** So it sounds like the, one of the important things for your business was in as you've said sticking to your strengths and very much recognizing your niche in this market and being able to do the things that other existing equipment can't do.

**Andy:** Absolutely, and I think that also one of the lessons that I've learned is to you know, keep it simple. Things get complicated enough on their own. So yeah, stick to your strengths and particularly if you’re a small company, you need to spend your resources wisely, so our initial business model was to put all of our efforts on to what *we* knew, producing a module focused on our competencies.

**Emma**: So you ended up with this this box, as you say box of electronics that other people can, to be very simplistic, plug in to their own equipment.

**Andy:** Absolutely, that's very much the concept of the business model.

**Emma:** Does it have to still be tailored to a particular bit of kit that it's working with, or is it fairly universal?

**Andy:** So it needs to be tailored and that's where building good partnerships and relationships with the companies that we're working with is absolutely key.

**Emma:** How much work do you think you do on the relationship side of things, as well as the technical side of things?

**Andy:** So me personally, I would say that - and particularly these days - I think more than half my time is kind of external facing talking to external parties and looking for new business opportunities. So a very large part of my job.

**Emma:** Is that something you think you already were good at or is that a talent you've had to hone, during the course of running your business.

**Andy:** I think it's a talent that I've had to hone, and actually right from the beginning of starting my PhD, I always put myself forward to present at conferences, and although it was not necessarily a very comfortable thing to do it’s very much something that I felt was very important.

**Emma**: So working outside comfort zones would probably be another part of your advice to people trying to make it out there.

**Andy:** Indeed yes, and that's hard work and you need to stick at it, and it takes sort of motivation, personal motivation, but yes, yes very much.

**Anne:** I was thinking about some you know that an early career researcher might be listening to this Andy and be quite inspired by what you're talking about. If an early career researcher was listening to this and thought they had some good ideas or just, say, help us understand how physics supported you in the University.

**Andy:** Well, I think the research group I was in, I was very fortunate that we had a lot of external connections, and so we had a lot of opportunities to attend conferences, to visit other research groups. You know if you go to a conference, it's more comfortable to present a poster. But actually, I think that if you put yourself forward, and you have the opportunity to present orally, you know…

**Anne:** Yes. Get out there and do it, people remember you.

**Andy:** Indeed, it really gives you a chance to build those relationships and make those connections with people.

**Emma:** Now that you've obviously got your niche in that market with the semiconductor industry, where do you see Infinitesima going next with its technology.

**Andy:** So Infinitesima and it's a company, so it needs to be focused and we're still a small company, and so, as I mentioned, you have to be careful how you expend your resources. So Infinitesima as a company is 100% focused on the semiconductor market and now that we have built up that experience and we've been in the market, the direction for the business now is to take the step of building our own tool, so you know I mentioned that we focused on the module initially, but now the direction for the business is to put the ancillary parts around that core technology and actually build our own tool and so that's sort of I guess the core direction of the commercial opportunity for the business.

But then around that we're now also starting to work with, you know, research groups so we were working with an internationally renowned research group called IMAC in Belgium and we're starting to look for other capabilities that our technology can bring, and one area there is that these microscopes - I kind of described them as this mechanical microscope, so you can not only feel a surface, but if you do it in the right way, if you increase the forces, you can actually manipulate the surface as well. Now normally you don't want to change the surface of the thing you're looking at, but in certain situations, you may want to manipulate the surface, and so one area that we're now looking at is performing tomography of surfaces, so we can use the tip to remove material from the surface and then we can use a second tip to image the surface, and by doing that sequentially we can then build up three dimensional tomographic images of samples. So those are the directions that we're primarily looking at the moment.

**Emma:** So it's kind of full circle - you started in research, you took that research out and made a company out of it, and now that's going back into other people's research labs to look for other applications.

**Andy:** Very, very much and and I think that for any company to be successful, you always have to be looking to the future. So continuing to look for new opportunities, continuing to perform fundamental research or you know, working with research institutes is a very key part of continuing, to the future of the business.

**Anne:** So a research intensive business, really.

**Andy:** Absolutely, particularly in a business or in areas like the semiconductor industry, which is always working at the forefront of technology, if you don't continue to develop your capabilities, then, you know, then you will be left behind.

**Anne:** And it makes me feel that you know you being Aegis Professor it's such a good fit, you can see, so why it's so valuable for both the researchers that here at the University to have your input and to understand that journey that you've been on, it is inspirational. But also as Emma says, that other research comes up so all the connections that we foster you can't always see where they're going to go, can you.

**Andy:** that's right, and I think I think that that's one of the beauties of the, you know, the academic environment is that very much I think that, the more flexibility, the more freedom to innovate and maybe follow those parts. It's a really privileged thing to be able to do but also really powerful.

**Anne:** Yeah but also to think about the application, because, as you said, and as I've heard lots of other researchers saying, knowledge for knowledge’s sake and having the freedom to do that is what universities are great at, but it's really exciting to see your work taken and have an impact as well outside.

**Andy:** Yeah I completely agree and I think this is one of the - I had a very difficult decision whether to stay in academia or move into industry and, because I was, I was all set for an academic career. I had the fortune to have a fellowship and actually that led into - I had a lectureship at Bristol which - and I was 100% committed to an academic career, but then, the I guess the kind of the responsibility of having started the company but also wanting to see that research through into a product, into sort of, commercial applications, is then what eventually pulled me out of pure research into the commercial world.

**Emma:** that's obviously, well as Anne says you're such a great fit for the Aegis professorship, you can have this foot in both camps, you obviously feel comfortable in the world of academia and the world of commercial business. Do you think there might be people perhaps who've developed a product themselves, maybe not in academia and are making a business, who might be a bit nervous about approaching academia, with their product, their work?

**Andy:** I could completely understand that and something that I've seen is that - having that background in academia does give you that comfort, that connection, and it is a very different environment, the academic environment. And I think it can be difficult to bridge those gaps and I would, you know, I very much hope that - and I'd be delighted! - to facilitate that conduit, and

I think that having that kind of opportunity through this Professorship would be tremendous.

**Emma**: So if maybe somebody in the commercial world had a product that they would like to take further that was maybe a bit nervous about taking it into academia, what would you say to them about what academia can offer them and perhaps what they could offer academia in return?

**Andy:** So I guess the commercial world can offer the focus and the goals of, sort of the requirements for what they need to deliver to create a product to solve people's problems. But the academic environment gives, I think it gives many things, but it gives a wonderful space to innovate and I certainly didn't appreciate that, when I was 100% in academia, how important the environment was. We always spoke about the environment and making sure that we had the space to discuss and think. But until you step out of academia, maybe you don't realize how precious that is and how difficult an environment that is to create. So the academic environment brings that, but it also brings great great depth in the expertise of the individuals in particular areas, it’s tremendous so I think, so the academic environment brings that space to innovate, also great great depth, and the commercial environment really brings a knowledge of what problems people in their everyday lives or what problems people would like to solve and therefore what products need to be developed.

**Anne:** I know that you've worked with Jaap who was our Faculty business fellow until recently, and have you had a PhD student working with you Andy? - Is that a way that we can work together on research that both allows the PhD student to pursue their career, but also meet some of your goals as well Andy, Infinitesima’s goals I should say.

**Andy:** Absolutely so, and you know I’ve been fortunate enough to have a really good relationship with Bristol University in other academic institutions, but you always need a common goal. Well you both have to have a win-win relationship, when you work on something together. And so recently we're actually very fortunate to, through an IAA grant - so an Impact Accelerator account with the University of Bristol, we had a student or a postdoc join us full time, to look at image analysis and help us understand our data, and so we were able to bring somebody from an academic background and actually he stayed very much within the academic environment. And he was able to bring knowledge of his, you know, quite different area of research, so he actually had experience looking at fossils, and he’d developed image analysis techniques for looking at fossils and he was able to apply those to our data sets with really wonderful results, and utilize a completely different area of study that brings great value to the business.

**Anne:** Again, it’s such a good story for, from our perspective, I guess at the Faculty of showing working across schools that I guess that could be geographical sciences or earth sciences.

**Andy:** Palaeontology.

**Anne:** Exactly, palaeontology. And yet that's applicable to the semiconductor industry, that's really, really great, and we should probably just say that that’s EPSRC money so that's kind of a government business and universities all working together there to try to get that impact out isn't it.

**Andy:** And I have to say, for us it allowed us to develop real commercial value and it resulted in joint publications and presentations at international conferences, so I think it was a great success on many levels.

**Emma**: As you're taking your professorship position - before, what obviously you started early this year bang in the middle of a pandemic. So I imagine that the things you'd hoped to be doing with the post perhaps weren't possible at first, but keeping fingers crossed and hoping we are going to come out of this gradually, what are you looking forward to doing during your post as Aegis Professor.

**Andy:** Yes, super, super question, and so it has been a challenge, Covid, for all of us. So it has made obviously face to face contact impossible, but I'm really pleased that through the support of the university, I have been able to talk to a number of students and, you know, which has been fascinating for myself, but also be able to share some of my experiences. Also next year I'm going to be involved in a number of final year projects which have a bit of a theme where, you know that there are links to things that Infinitesima has interest in and so there is an opportunity there for people getting involved, and to also see even what they're doing at a final year project level could have, you would definitely have value outside their immediate academic kind of focus.

The very nature of the semiconductor market always being at the forefront of technology, is always looking for new capabilities and there are absolute genuine metrology measurement challenges which do need innovation, and it would be lovely to see if there's areas that can, within the university, that can feed back into that as well.

**Emma:** So we're looking forward to having you with us for a few more years which sounds like it's gonna bring an awful lot of opportunities into Bristol. We've had a lovely rambling chat Andy, is there anything that you haven't managed to say yet that you wanted to bring up?

**Andy:** No, I think you've given me a wonderful opportunity to share some of my experiences and my thoughts and hopefully, if people hear this, they, you know I'm very happy for people to reach out and would be delighted to just find ways to engage with the university.

**Anne:** I just wanted to say, thanks Andy, you really brought your experiences to life for us, and I think it'd be fun to explore some of those things a bit more in the future as well, thanks so much for your time this morning and for all the great work you're doing as Aegis Professor.

**Andy:** Well thank you very much, been very enjoyable.

**Emma:** Thanks Andy.

**Further information and contacts**

You can contact the SPO via

Email: [scif-spo-enquiries@bristol.ac.uk](mailto:scif-spo-enquiries@bristol.ac.uk)

Twitter: [@SPO\_Bristol](https://twitter.com/SPO_Bristol)

LinkedIn: search for SPO Bristol or [view our Page](http://www.linkedin.com/company/science-partnership-office-bristol/)

See the SPO website, [www.bristol.ac.uk/science/science-partnership-office/](http://www.bristol.ac.uk/science/science-partnership-office/) for further information about Aegis professors.

Infinitesima’s website: <https://www.infinitesima.com/>

The ZEISS MeRiT neXT tool:

<https://www.zeiss.com/semiconductor-manufacturing-technology/products-solutions/photomask-solutions/mask-repair.html#productblockmeritnext>