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Duncan Foster Fitzsimons

This podcast is an initiative of the Commercialising Metamaterials Innovations Network, a community funded by KTN. The innovations network aims to develop and showcase applications for metamaterials, building a community of academics, industry stakeholders and investors, and aims to make these technologies more commercially accessible to markets. If you haven't already, go check out the KTM page. You can connect with our community find the latest news, take part in our events, or funding opportunities, and much more, you can find the link in the description of this podcast. I'm Duncan Foster Fitzsimons, I'm a designer and engineer and founder of the 7TH Product Design Studio. Today, I'll be talking with James Johnston, Director of programme management at Advanced Materials Developments. I'm really keen to find out how James approaches design in metamaterials, how people like myself working in product development can make use of these incredibly unique materials, and to swap some notes on the creative process. So hello, James. So it's great to talk to you. I'm really interested to hear all about how you work with metamaterials, what you do with them, how you how you create them. But I'm going to kick off with a deliberately stupid question, which is what is a metamaterial? I know, a lot of people like me out there probably have a slightly wrong idea about about what these things are?

James Johnston

Yes, yeah, we have constant debates in the office what a metamaterial actually is, so it's a live subject. So as far as far as we're concerned, it's a material which exhibits properties that don't normally exist in nature. So, so basically, what that means is that they are synthetically engineered to exhibit properties normally, that interact with some kind of radiation or, or sound wave to produce effects for engineering and science that people require for lots and lots of different purposes. So, yes, so normally, those sorts of materials have some kind of repeating element to them. And they may have different types of materials structured in different ways. So that when put together in the bulk, they exhibit these rather strange behaviours.

Duncan Foster Fitzsimons

And so does that mean that these metal materials they are designed by you to to exhibit a very particular behaviour each time?

James Johnston

Generally, yes, I guess some sometimes there's a bit of serendipity. But normally, there's an element of being able to understand essentially, the structure and property relationships between matter and space. And that sounds quite highfalutin, but normally, so your matter has been obviously, matter is composed of atoms and electrons and things like that. And electromagnetic waves have a strong interaction with matter. So what you're trying to do is to match properties, and hopefully predict some of the, the after effects. Now, it's quite a complicated process. And I think that some of this if we go way back was described in the equations of Maxwell, which are fiendishly complicated, and I don't profess to understand them properly myself, but there's lots of people in the academic world who understand the

interaction of light or electromagnetic radiation and matter. So designing these things is quite a complicated process.

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And with your work at AMD Nano, is there a particular type of material, type of application scale of metamaterial that you guys specialise in and are particularly focused on?

James Johnston

Yes. So, we have, generally, we kind of pitch ourselves as addressing most of the electromagnetic spectrum. So we have, what I would say is two platforms. So we are specialists in 2d nanomaterials. So things like graphene, and other 2d materials. And we also have our, what's called polymer opals or photonic crystal platforms. So there's two different, we have two different streams of technologies that that we do. So most of what we do in the graphene area is pretty much to do with the kind of lower end of the electromagnetic spectrum. So we do everything from modifying the emissivity of surfaces, we can also print shapes that interact with radio waves. And then our other technology platform, which is the photonic crystals, were able to modify the properties of reflected or absorbed light. So we, we spent quite a lot of time, in fact, most of our time tuning those structures and materials to give us the properties that we want. So we're balancing lots of things between how you synthesise these structures versus how thick they are. And what other composites are present around these structures.

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Is it fair to say, that sounds to me like a lot of it is, is on a very thin layer or surface layer, is that correct? And then you're looking at how it interacts with other layers, that it's layered, like a sandwich between or put on top of.

James Johnston

Yes, so certainly, in terms of, say, our RF metamaterials, we would say print those and structure them onto another surface. Now you can layer those structures up in various ways and tune things like the material permittivity, which will modify things, you can also vary things like the shape of the thing that you've printed. So lots of people do repeating arrays, and you can you can print those in different manners. Now, the photonic crystal is more of a thicker material, I would say, although it can go very thin. So what we tend to do there is try to make kind of thicker crystals. So in that sense, we're tuning the additives that go into these photonic crystals. So we have a patent pending system from the University of Surrey, that we can exploit and we're constantly looking at modifying those materials to make the effects that we want.

Duncan Foster Fitzsimons

And when you when you say a thick material, I suspect it's a lot thinner than what I usually call a thick material.

Unknown Speaker

Yes. Now, we're not talking centimetres or millimetres here. So this is always the confusion, somebody's thick is another person's thin. So you're absolutely right, you kind of need to think about the length scales of some of these things. So for instance, some of our radio

materials, they're actually quite thick, they might be I don't know, between 50 and 100 microns, which is normally about the width of a human hair. And then other structures which we have made in the lab using techniques like Landwehr Blodgett films, which are very, very thin indeed, those could, those could be 100 or so nanometers. So they're very, very thin. But if photonic crystals could be made, I don't know, a few hundred microns, so probably about the thickness of a piece of paper or a piece of card or something like that. But I'm well aware that there are, you know, other metal materials and structures that are much bigger than that. And you might use 3d printing, for instance, or injection moulding for those macro structures,

Duncan Foster Fitzsimons

We'll come onto this a little bit later, I assume there's a certain number of limited processes available to produce these. Yeah, okay. So one of the things, I'd like to ask is, is, so in my line of work, in product development, I'd say nearly every project we ever work on, we're either trying to solve a problem for someone, so someone needs something to work and it doesn't work. So we need to create a mechanism or something to achieve that. Or we're talking to someone who has an opportunity, you know, there's a market gap or something and we're, from a clean sheet, trying to create a new product or a new object that meets that need. Is it a similar thing from your side? Are you always responding to a particular problem that needs solving when you're creating a new material? Or are you sometimes exploring promising areas and then looking for opportunities to deploy those new materials?

James Johnston

Yes. It's a good question. I guess what we have, in terms of our armoury, we have a set of technological solutions, which could be applied in all sorts of ways. And we normally, it's normally within the team, we have some very creative minds that are constantly looking for different application areas. So if I take, for example, our photonic crystals, our Fellowship Award with Izabela Jurewicz we sat down and dreamed up a load of possible applications that could be used. And she's been working on these for 3, 4, 5 years. So it's a case of, I guess, it is inspiration. That's what I'm saying. And then it's, some of it is then driven by the business needs. So we just recently completed something called scaling the edge programme with Belfast University. And this was looking at the market opportunities. So, so we might have a madcap idea, we might have 10 Madcap ideas. But then we've just been through this programme to sift out whether there's actually a market for it or not. So that's what we tend to do. And not every idea is successful. But we generally hear those and ideas from the community, there's kind of themes that people are working on at the moment. So one big area might be for looking at 5G antenna. So there's lots of organisations in the UK looking at those types of things. And metamaterials can have an impact on that area. So we're minded to try and work out some solutions for that.

Duncan Foster Fitzsimons

And when you see new materials in your space sort of catapulting themselves into market first or coming out of nowhere, and I'm imagining what's the metamaterial equivalent of the iPhone, sort of taking the market by storm? Is that happening? You know, as part of larger development programmes, or is it something that, you know, people are just sort of happening upon by chance? Or or is it where people are pursuing a particular particular sort

of end goal and just just throwing everything at it research wise? Do you see certain strategies that seem to pay off in that way?

James Johnston

Yeah. Well, I think a lot of very innovative stuff is coming out the universities. So I don't profess to know their minds. And how they inspire themselves to invent these new things. But yeah, it's a combination of kind of finding that there's a lot of very active academic materials research out there. And constantly sifting through those. And yes, there are sort of platforms and ideas that emerge. That you think, Oh, well, actually, we could do quite a lot of that. I guess, the most kind of exciting bit for us is our polymer photonic crystals. So those have emerged in the last 10 years. And those have emerged from very high standard labs. So places like Harvard and MIT, places like that. And Cambridge University. So it's looking at the initial wow factor, and then thinking, Oh, how can we utilise some of this in some in some novel application? So it's, I think a lot of it's from the the academic base, but the issue is, it's how to surface those ideas into industry so that they can pick them up. So sometimes those communities, there needs to be a bridge between those communities.

Duncan Foster Fitzsimons

So on that front, across a lot of different new technologies, you often see barriers that, you know, hold back technologies from getting into sort of mainstream market applications, until those barriers are suddenly overcome and then they sort of float out into the market. Sometimes that can just be that people don't know these technologies exist, or they haven't seen them be demonstrated in a certain way. Sometimes it can be problems of scalability. You know, you can create something in the lab, but it's difficult to ramp it up to the mass production scales. What do you think from from your side? Are there certain things that apply generally to metamaterials as challenges to overcome next in order to to sort of break open wider scale deployment of these these technologies?

James Johnston

Yeah, I would probably I would probably agree it's, some of this is coming. But it usually boils down to, can you produce these in sufficient quantity or larger area at a reasonable cost? Reasonable cost is usually the determining factor. One of the huge barriers that I have seen over the years is, is taking something that essentially is some experiments in a fume cupboard or a cleanroom. And trying to scale that into something practical. So sometimes the scale up equipment or machinery doesn't actually exist, so what that means is that you have to invest, there's a there's a significant investment of time and money in equipment and development of manufacturing processes that needs to occur. And that can cost, well, certainly seven figures. Not in all cases. But if you have to put together a significant process that's going to take a lot of time and effort. And industry in academia doesn't have access to all of the pieces of process equipment that it needs to be able to do all of this in one consistent way. It can be quite expensive. Yes.

Duncan Foster Fitzsimons

But it doesn't sound all bad though, I guess. I mean, is it correct to say that, in theory, it's possible to scale up these processes, but currently expensive. And so there needs to be this sort of, I guess, sort of coming together of a killer application where everyone involved can see it's worth investing in, in order to get to the end result? And then in theory, yeah, that

the processes can be scaled up and can be deployed and applied in different ways. Once everyone gets on board, as it were.

James Johnston

Yes, yeah, certainly. And I see the role of collaborative projects are very important here. So because they're, because they're expensive and high technical risk and high financial risk, it makes collaboration through public funded, like the UK Government, or the EU very important to de-risk this. It's a great way to develop these things. And you need to think about how you're developing the potential materials supply chain, at the same time as innovating these things. There's many elements that come together, and it's not so easy. And I think innovators spend probably 99% of their time trying to figure out how on earth to put these things together. That's the hard bit that goes to the crux of what you're trying to do.

Duncan Foster Fitzsimons

Yeah, fair enough. So on that front, without giving away any big secrets, in general across the your field, do you see any particular metamaterials that you think are sort of going to be the next big thing or if I was to sort of tell my friends and family about it? You know, is there other metal materials that we already have in the home that we don't know about? Are these materials going to start to sort of change our lives in one way or another of the sort you'd see in the newspapers?

James Johnston

Yeah, I guess I suppose the thing, it because a lot of these materials that you they sort of embedded in the fabric of everyday objects, so you probably wouldn't even give it a second thought so I think one area that I've always had that is sort of interested me is around noise pollution around the home or the office or generally, and, and we're talking about macro structures here. But noise abatement using metamaterials is I think, sort of a real obvious application at the moment. So I think that's exciting. And also, I guess the other sorts of things you might notice in everyday world are things like security stamps. So making things like false colours, or making structures that are very, very hard to reproduce is a very simple demonstration of a metamaterial or a metasurface that can provide assurance to people that the articles that they buy are genuine.

Duncan Foster Fitzsimons

Does that does that sort of cross into sort of holograms you get on your sort of debit card and things like that.

James Johnston

Yeah, that's right. So, we do live with metasurfaces and metamaterials all the time. For another example, somebody might invent a light capturing structure for a solar panel. So invent a concentrated system, now, you probably wouldn't notice, you would just buy the solar panels, because on the basis of efficiency, because they were better than the ones that didn't have them. So creating those structures could have a very large impact on the amount of electricity you could generate, or keeping things cool. So structuring things in a way where you could offset the amount of, you know, the climate emission, so they do have such a broad applicability, the trick is to focus, as we constantly say in the office, and pursue

those to their conclusion, it's very easy to get caught up in all sorts of fancy things, and lots of exciting opportunities, but the wealth is generated from focusing on one or two things doing very, very well.

Duncan Foster Fitzsimons

Right. Well, as a sort of a big sort of final question, I think it would be if there are manufacturers out there, companies developing products, companies, manufacturing materials and products, and they are looking to get into metamaterials to find out how they can even get into manufacturing metamaterials, or how they can apply metamaterials to help improve their their products and services. What what should be their first step? Do you think?

James Johnston

Well, yeah. Of course, they can come and talk to us. But I think it's also searching the academic journals might take a little bit of time. I think things like events, highlighting what people are up to, especially I think, with KTN, provides access to people finding out what on earth is going on in this area. And then, you know, talking to companies like us, or talking to people in the know I constantly find there's a there's a treasure trove of stuff if you open the box, there's a lot of there's a lot of very innovative science out there. But yes, it's the, as I said, the connection between the real world application and the sort of fundamental principles that's really the key. And, I think it events and just talking to people is the key.

Duncan Foster Fitzsimons

Yeah, brilliant. Okay. Well, thanks very much, James. It's been brilliant. Thanks for your time, today and for sharing your expertise. I've learned a lot and thank you everyone for listening. Hope you enjoyed this discussion and and learn a little bit more about Metamaterials In Design. Don't forget to visit our website in the description and register to the newsletter to receive news and updates. To take part in our community. You can follow our podcast channel on Podbean and make sure you don't miss out on our next episode with Anne Toomey, Head of Textiles.

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