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Impact of a University Spin-In Company on Academic Research: A Case Example*

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This paper provides an example of how a collaborative research engagement with an advanced technology start-up company has had considerable research and educational benefits to the host academic institution. The start-up company had developed a novel microblast based coating technology for use in the medical device and aerospace sectors. After an initial collaborative research project, the company relocated into the university, renting space in a business incubator unit and also in an engineering laboratory specialising in Surface Engineering. This paper provides an overview of the student impact of the collaborative research activities and details how Irish Government supports facilitated this engagement. As a result of this collaboration to-date 5 post-graduate students are working on projects directly associated with the start-up company and 6 journal papers have been published.

Keywords: industry academic collaboration; research-led; entrepreneurial environment

1. Introduction

It has been highlighted by a number of authors that research, teaching and learning are inextricably linked, and that linkage is a critical part of the education continuum [1]. Academic institutions have in-depth technical knowledge in specific areas, which can be of great benefit to a high tech start-up. In order to engage with this type of company the academics must identify a technical challenge associated with the company's technology, which can be the focus of student projects (for example) and in order to facilitate a high level of engagement there must be either financial support directly from the company and/or from governmental agencies. The focus of this study is the interaction between a group of researchers in a university and a start-up company who had developed and patented a novel coating technology. This start-up has to-date mainly focused on the medical device and aerospace sectors. It is a pre-revenue generating company, however based on the potential of its technology, in addition to funding from investors it has been able to secure significant research funding both from industry partners as well as Irish Government and European research agencies. The ability to secure this funding reflects the advanced nature and novelty of its coating process developed to apply inorganic coatings onto metallic surfaces. This technology called CoBlast [2], involves ablating the metal surface simultaneously with both hard and soft power particles, which are entrained in a powder jet (Fig. 1). The process is similar to microblasting except two powder particle types are simultaneously bombarded against the substrate.

Coatings such as hydroxyapatite, Teflon and graphite have been deposited using the CoBlast process on metallic substrates from their respective powders, which were combined with hard abrasive particles such as alumina or MCD (a sintered Hydroxyapatite). When the company initially approached the university they did so in order to obtain assistance in determining the fundamental mechanisms under which the mechano-chemical bonding of the coating to the substrate was achieved. This was a technically complex issue for which a number of advanced surface characterization instruments are required to examine both the deposited coatings and interfacial properties. The Surface Engineering Group based within the School of Engineering within the university, had extensive in the expertise in the deposition and characterization of coatings developed over a period of over two decades [3]. With support from the Irish Government under the Innovation Partnership programme [4], the company provided a CoBlast deposition system to the university to enable its researchers to carry out coating studies. This Government support along with 20% direct funding from the company facilitated the initiation of the research engagement for a period of 2 years. Since this initial engagement there has been a further 3 years of research collaboration focused on both developing novel applications of the coating technology as well as obtaining a fundamental understanding of the deposition process.

2. Teaching-learning methodology

The teaching-learning outcomes were mainly based on the research carried out by post-graduate students working on the CoBlast technology. There

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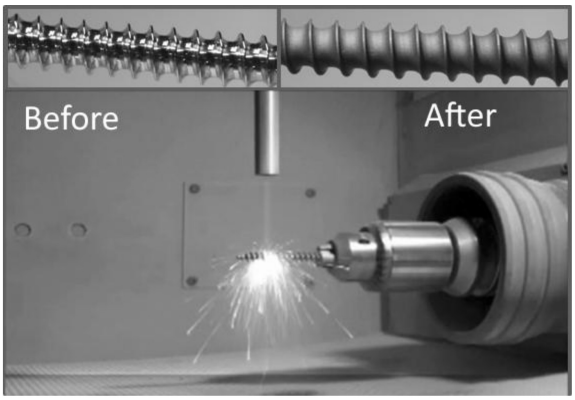

Fig. 1. Photograph of a CoBlast nozzle used to deposit hydroxyapatite coatings onto titanium implant screws. The sparks are associated with the rapid oxidation of titanium particles which are ejected from the screw surface by the abrasive particles. The top image shows an example of uncoated (before) and hydroxyapatite coated (after) screws. The latter coating has the potential to enhance the level of cell attachment to the screw surface when implanted.

have also been positive benefits at undergraduate level with a number of students taking projects related to the new coating technology. Finally there has been broader learning by incorporating material from the research work into undergraduate and taught master's lectures. One of the principal areas of research focus was on understanding the process under which two types of powder particles (hard and soft), arriving at a metal surface during the CoBlast process and yield coatings which exhibit good adhesion. After investigating the influence of deposition parameters on the coatings the adhesion issue was investigated using a range of techniques such as SEM, TEM, EDAX elemental analysis, scratch adhesion etc., it was concluded that the adhesion mechanism involved both mechanical interlocking and chemical bonding [5, 6].

Due to the fundamental issues in understanding the CoBlast bonding issues, along with the novelty of the deposition approach and its potential for application in a number of different sectors (including medical devices, aerospace and adhesive promotion), the academic partner was able to leverage further Government research funding under the Science Foundation Ireland, CLUSTER programme [7]. This programme involves 2 different university partners, 5 Principal Investigators and 7 industry partners. Using funding from this programe two PhD students were recruited and included in their research work was the investigation of the CoBlast process deposited coatings. One student's research was focused in the area of surface engineering, while the second evaluated the biosurface interaction of the coatings (particularly cell adhesion). This engagement involved two academic staff in two different University schools. While these two staff members had not previously collaborated and this joint research programme facilitated a high level of collaborative research (including joint publications), between the two research groups [8]. While the company did not provide a significant level of direct funding into this research programe, they provided a considerable level of technical input including engineer time, raw materials etc. Their very active involvement in this research along with a number of other companies involved in unrelated collaborative projects with the university were key to securing Government support for this CLUSTER research programme.

As the level of collaboration between the start-up company and the University increased the formed increasingly recognized the value of this engagement and made the decision to 'spin-in' to the university. This involved the start-up renting a business incubation unit within the university, as well as laboratory space to house its three CoBlast deposition systems. This move involved the relocation of five company personnel, two of the technical team (educated to PhD level), were located on a fulltime basis in the Surface Engineering laboratory. Following this spin-in, three further students at Masters of Surgery (MCh) and PhD level were recruited into the Surface Engineering Group, to carry out research based on different aspects of the developed technology. These students were not supported directly by the company but were funded under both their own funding and other Government programmes. Details on the five post graduate students carrying out research based on the CoBlast coating technology are given in Table 1.

3. Main results/Actual benefits of academia-industry collaboration

Collaboration— As detailed earlier there has clearly a strong level of engagement with the start-up company from the initial Innovation Partnership project, which in turn led to its decision to spin-in to the university. This engagement was enhanced through a strong mutual respect, good communication and the recognition of a win/win opportunity for both partners. In order to facilitate the company to gain access to laboratory space at the university, it was necessary to provide that space by removing equipment which had limited research usage. A significant re-organisation of the equipment within the Surface Engineering laboratory was also undertaken. The decision of the industry partner to locate its equipment in the laboratory of the industry partner was however key to fostering a higher level of engagement. A critical factor was also that two company researchers located in the university

Table 1. Post graduate students carrying out research based on the CoBlast technology

PhD1—Funded under the CLUSTER programme carried out research on fundamental issues influencing the adhesion of CoBlast deposited hydroxyapatite (HA) coatings to medical devices. The coatings were benchmarked against those deposited using the widely commercially used plasma spray process [5].

PhD2—Also funded under the CLUSTER programme, this student had previously trained as a surgeon. He carried out both *in-vitro* and *in-vivo* (rabbit) studies on CoBlast and surface modified CoBlast coatings.

PhD3—This student work on the CoBlast technology as part of a broader PhD research programme on the deposition of titanium oxide (TiO_2) coatings. The focus was on evaluating if plasma diagnostic (optical emission spectroscopy) and bias voltage measurements could be used as the basis of monitoring and controlling the CoBlast process. This research was carried out with assistance from academics in two universities.

PhD4—This student carried out research on applying the CoBlast technology for the deposition of Teflon and graphite carbon coatings. Cell attachment studies are carried out.

MCh1—This student was carrying out his masters of surgery degree and his research focus was on evaluating and comparing the mechanical and material properties of CoBlast and Plasma Spray deposited HA coatings on orthopaedic screws. Cell attachment studies were carried out in conjunction with the same collaborative academic who supervised the research programme of PhD2.

laboratory. The collaboration extended not only to the academic within the Engineering School of the host university, but also to collaborating academics working in bio technology (i.e. cell attachment, *in-vivo* studies), as well as process monitoring and control as detailed in Table 1.

In this type of collaboration where a company has researchers based in the university laboratory, procedures for the protection of know-how, disclosure of information by both sides, laboratory visits as well as the handling of new discoveries where the academic Group are involved have to be agreed and documented. For this case the university, Innovation and technology transfer centre called Nova [9], formulated the agreement on procedures to be followed by both parties. The building of academic/industry partnerships as well as supporting start-up companies is core to the academic/business support role of Nova. The day-to-day engagement between the academic/company researchers is clearly critical for a harmonious relationship. This takes time, not only for engagement amongst the two groups of researchers, but also between the academic staff and company management. If this engagement does not take place then problems arise, involving issues such as laboratory space usage, access to the laboratory by other research groups/visitors, usage of consumables etc. As in any collaborative arrangement the mutual benefits for the two parties must continually be demonstrated, particularly based on the research outputs.

Impact on the start-up company—has gained from the direct access of a number of academic researchers in the university, as well as their personnel being trained in the operation of a suite of characterization equipment. The deposition and materials characterisation studies as well as both *in-vitro* and *in-vivo* studies carried out with the university hosts have being very beneficial for the company. It has enabled them to obtain a fundamental understanding of its coating deposition process, the performance of its coatings as well as in the development of a process control technique. Without this support the company have highlighted on a number of occasions they would have had extreme difficulty in securing engagement with their industrial end-users, which in turn has been critical in helping them secure further developmental funding for their coating technology.

The company/university engagement is constantly evolving. The generation of income through the application of its technology either directly through internal manufacture or through technology licensing is vital for a company. Its very survival is dependent on generating revenue within a time period, which will be specified by its investors. This can put considerable pressure on the entrepreneurs to focus on short term revenue generation issues, compared with the longer term focus of post graduate research projects. This can create a tension between the expectations of the industry partner and the need for innovative publishable research, which is the requirement of the PhD students. This difficulty did not arise in the case under study as the funding for the PhD students came through Government supported projects. Thus there was independence between the PhD research work and any short-term company focus. In this respect the activities were carried out independently but from the academic supervisor's perspective the aim was also to focus on research activities which have potential long-term commercial application for the company. Thus the aim was to secure the continued support of the company through engagement of their personnel in the project, the use of company equipment, materials etc. In this regard there is mutually supportive engagement.

Research/Educational Output—This collaboration has enabled researchers at the host academic institution to carry out research on inorganic powder coating deposition and characterisation. This is a new area of research for them, with considerable potential for development, particularly in the deposition of well adherent novel coat-

ings. As part of the research programme the host institution designed and constructed one deposition system, with assistance from the partner company. The university researchers have access to two of the companies own systems. Direct engagement with the start-up company has assisted in securing Government funding support, as many of their programmes require research, which has demonstrable medium to long term industry impact.

For the research students there have been a number of positive benefits arising from the engagement with the company:

- Investigation of a novel technology—This has allowed the development of a new research area within the university and has facilitated student publications. As detailed in Table 1 the students are engaged in a diverse range of project areas which help to demonstrate the breadth of the technology engagement. In addition to post-graduate students, undergraduate students are also involved with the company working on final year projects ranging from coatings materials evaluation, to identifying the issues required to bring a medical device coating technology through the regulatory hurdles. Having a 'real-life' example is clearly very powerful in the case of these projects. Thus the teaching philosophy can be considered as research-led i.e. through their engagement the students are exposed to current research being carried out with the laboratory and thus there is a close correlation between research and teaching activities [10].
- Collaboration—This has been very important as the students have had a high level of engagement with company researchers. This has certainly assisted them with their research projects. A further aspect has been the engagement between researchers within different university schools as well as different universities. This engagement has facilitated a broader learning opportunity for the students to learn about areas not directly associated with their specific research project. A further learning outcome is that the students have obtained direct experience of a start-up and its focus on commercialising a new technology, including issues such as meeting end-user performance criteria, the importance of IP protection, managing innovation etc. This access to the practical entrepreneurial environment is a very valuable learning experience should assist them enormously in their future careers.

At the time of writing this paper a MCh and a PhD student have both graduated based on research carried out on CoBlast technology. Six peer reviewed publications have been published to-date [5, 6, 8, 11–13], with a further 2 papers under review. In agreement with the company no publications are submitted without giving them time to review the paper and possibly seeking to protect any developed technology. The company has no influence over the content of the information submitted for publication, which is obviously critical for independent academic evaluation. The awarding of post-graduate qualifications along with the publication of peer reviewed papers directly focused on the CoBlast technique provides quantitative indication of the research learning outputs resulting through the engagement with the start-up company.

As highlighted earlier a benefit for the students working on projects with the start-up was the direct engagement with the industry researchers. In conjunction with the researchers from academia the industry researchers assisted new students in the development of their research skills and the potential end user application of their research was clearly evident. Amongst the comments from the PhD students are that this engagement gave them an understanding of the importance of an SME being 'nimble' in identifying new opportunities. For example one comment was on how "Continued understanding and innovation of the a company's technology/product is more important than consolidating on one form of the technology/product, as it leaves more potential for a change in company focus going forward".

A further educational impact achieved through the collaboration with the start-up company has been the use of research findings in lecture material provided to undergraduate students. This has included direct use of examples within thought modules of material obtain from the joint research programme. This has included the evaluation of powder particle size, the measurement of particle velocities, the use of characterization techniques such as SEM and XRD to examine inorganic materials. Material from the cell and *in-vivo* studies carried out on hydroxapatite coatings have been used as case examples for a thought module in nanotechnology. It has been highlighted previously that research findings and teaching practice do not exist in isolation; rather, research and teaching are in constant communication [14]. Research results can be used to generate material which informs teaching activity and also to help keep course material at the leading edge of technology development.

It is important to note that an additional advantage for the host academic institution has been the promotion of the universities surface engineering research activities through the engagement with the start-up company. This has been achieved through the company personnel meeting with end users and highlighting their direct engagement with the uni-

versity researchers. The Irish Governmental industry development agencies strongly encouraged engagements of this type as they have the potential to foster high technology start-up companies which in turn can go on to generate significant numbers of jobs.

4. Future issues

The initial focus of the research work with the start-up company was to investigating their new technology, exploring applications and trying to obtain a fundamental understanding of the bonding mechanism. As in any new research area there is an initial period when papers can be published with relative ease, due to the novelty of the technology and unique applications. As the number of papers in the research area increase, not only from the core research group but also other groups, who are also investigating the technology [15], then any new publication has an increased level of difficulty to continue to demonstrate the novelty of the developed understanding and/or application. The rate of technology maturity from a publication perspective is therefore dependent on the number of individual researchers /groups investigating the area as well as the complexity of the research topic. In the case of the CoBlast technology the focus to-date has been on HA coatings, evaluation issues such as deposition parameters, benchmarking the coating with the alternative plasma spray technique, examination of the effect of different abrasives, substrates, cell attachment etc. As the gaps in the understanding of the HA coatings deposited using this technology are filled, going forward future publications are likely to increasingly on non HA applications of CoBlast. The academic potential for the broader coating applications of the technology are still being explored.

A further issue is the constantly changing nature of the company, in its initial start-up phase there is a strong dependency on the university staff to assist it in understanding its new technology. The research publications help to underpin its new technology for early industry adopters of that technology. As the technology matures the relationship changes, if the company generates significant revenue it will invest in its own independent facility and perhaps hire graduate students completing their research within the university. If the company is unsuccessful the post graduate student projects clearly have to be structured so that they can be completed without any significant impact on the research outputs/ timing. The importance of the independent Government funding for the PhD students is clearly critical in this regard. Overall the interaction between the start-up company and the university is constantly developing over time and is clearly dependent on the start-up company achieving commercial success.

5. Conclusions

This paper provides an overview of the collaborative research engagement between an advanced technology start-up company and a number of academics in two different universities. The benefits for the undergraduate and postgraduate students of engaging with the start-up has been to carry out research on a novel, industrially relevant technology, as well as to have the opportunity to engage directly with the company funded researchers. This has resulted in a number of peer reviewed publications based on a fundamental understanding of the developed technology. The students both at undergraduate and post-graduate level obtain direct experience of 'real-life' technical issues associated with their involvement with the start-up company. In addition their exposure to the entrepreneurial environment should assist them in opening up new career perspectives going forward.

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