Industry-Academy Research Framework on Electronics Hardware Innovations

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ABSTRACT

New technologies are needed to put on the market ever accelerated schedule in order to design and fabricate devices that fulfill consumers' expectations. An industry-academy collaborative working mode is very efficient way to accelerate and diversify progression of novel technological solutions, educate new multidisciplinary professionals, and to act the function of new business incubation. This type of long-term research activity strengthens the position of research groups from small countries in an international competition.

I. INTRODUCTION

The product offer that delights customers today will be a must tomorrow. New innovations are needed to provide tomorrow's delighting experiences. Current small size electronic devices and services that are available are good evidence of continuous innovations. Technological solutions and inventions that have emerged from academic research have speeded up the exploitation path. Industry's role is to cultivate academy results to serve customers and motivate to tackle tomorrow's challenges. In the field of electronics, technological changes have to be continuous such that tomorrow's delights are enabled. These new technologies will be increasingly based on the combination of inventions from several branches of science. Integration of new and established technologies to produce a functional device concept is one way to cope with this technological change [7, 10].

The electronics industry and academia have been closely intertwined. The industry has been present in areas of significant academic concentrations. It will take about ten years to bring these results – especially the major new technology – to the market. Traditionally, industry supported academic research has been focused closely to the exploitation phase. Technology demonstration has been supported through direct funding and the creation of lab facilities in order to test and demonstrate potentiality of the received solutions [1, 2]

Survival of electronics industry is based on continuous innovations as a result of own R&D efforts, and it is bound with intense research at universities and research institutes. The cooperation between academic and industrial research has intensified dramatically over the last years. One reason is that technology networking is required to establish low cost and high volume production infrastructure. Heartbeat of internet is driving to open industry-academy research framework to speed up innovations. The elements

in such joint research are an industrial consortium, lablets between a university and one company, strong basic research work by research groups, and focused research projects. [4, 12, 13]

This paper reports the experience of a university group working together with industrial partners to create collaborative framework for a new integrative technology development. It draws upon a long-term industry-academy relationship in the research work of electronics miniaturization at Tampere University of Technology (TUT), Finland, with industrial partners from the Finnish electronics and paper industries. In addition, the paper discusses the benefits and challenges of such collaboration [4, 12].

II. CREATIVE COOPERATION

Novel electronics devices are based on cooperation of companies specialized on several branches of technology and science. No one company can internally create the leading edge competence on all technology fields. Furthermore, proactive competence creation requires close cooperation with research communities in academy. An integrative technology is defined as a possibility of crossing the boundaries of existing business lines by exploiting existing and new technologies as well as the competences provided by new and old R&D network parties. Technologies of this type have to be developed and produced within networks in order to decentralize risks and costs. [7, 8]

It is impossible, or at least prohibitively expensive, for one company to create all the competences necessary for an entire infrastructure to exploit a new integrative technology. Moreover, one company cannot play all roles in the future value network. Hence, it is important to have partners that could use the technology in their products to commit themselves to developing a new technology at an early stage. A technology should be developed simultaneously with a future value network in order to accelerate its commercialization [3, 4, 10].

The main reasons for establishing industry-academy collaboration combined with an industrial R&D network are accelerated competence creation, intensified knowledge transfer, creation of a new value network, sharing of costs and risks, and education of multidisciplinary professionals. Partnership with a university is often motivated by access to critical competencies that allows companies to reach a high-level multidisciplinary knowledge base. Of course, the desire to share research costs is another key motive. Universities are primarily motivated for industry-academy cooperation by the need to find funding. Moreover, the government policy on research funding is now another incentive for closer industry-academy collaboration. [1, 2, 12, 13]

Partnership begins with a common vision and an express need to make it work. The companies in a consortium may have very varying expectations about a new technology because of their different position in the value network or their company strategy. In addition, academic partners have their ambition to fulfill. Traditionally, academic partners have set their priorities on basic research and industrial partners on applied research. In other words, research scientists prefer to bring to light unknown phenomena rather than develop applications, whereas developers in industries go for business potential of an innovation. [1, 2]

Starting up multidisciplinary industrial-academic collaboration is not an easy task. There are communication challenges, intellectual property sharing problems, and discussions regarding the sharing of cost and benefits, among others. [1, 2]

In this type of collaborative framework, one of the main challenges is to translate the expectations and assumptions of all parties involved into new technology solutions so that all in the collaborative framework feel they obtain benefits. Inter-organizational trust is a key factor to research collaboration success. Mutual trust

increases fairness of partner behaviors, brings good fait in the intents, magnifies reliability, reduces the potential for conflicts, and allows open information flow between the partners. In addition, recognition and valuation of the partner's competence background enables role differentiation in research work intensifying utilization of allocated resources, and increases both partners' commitment to the collaboration's targets. Authentic inter-organizational trust takes time to grow. [4, 12, 13]

One of the most important aspects of the collaborated research is its dynamic nature. Action by one party forces the other party to react in order to maintain the partner's commitment to the common targets. Functioning collaboration strengthens and expands knowledge base of one participant, because every party can allocate their own resources into their strongest knowledge area and share their knowledge with all other parties. In return they can learn from other parties about all other knowledge area. This intensifies the generation of knowledge. We would like to emphasize that this kind of working mode requires the well-defined roles for parties, no business conflicts within collaboration, truly trustful relationships between participants, and respectful attitude to each other. [4-6]

Industry-academy collaboration is an accelerator to transfer of academy research to commercial applications. Figure 1 illustrates the principle idea in the industry-academy collaboration combined with an industrial R&D network. At the core of the collaboration is academic basic research work, while in an outer layer surrounding this research is the industrial network, i.e. value network that can create and deliver commercial applications. In this figure, the middle layer illustrates industrial-academic collaboration and its function as an accelerator in knowledge creation and the transfer of this knowledge from academic basic research to the industry for commercial applications.

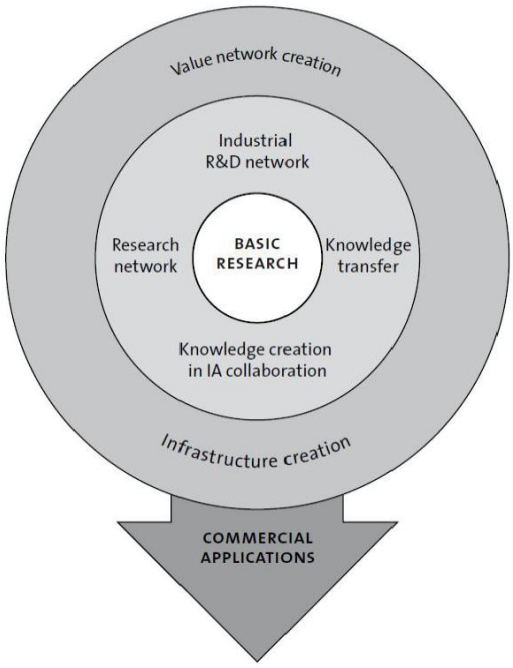

Figure 1: Industrial-academic cooperation in new technology development

This collaborative working mode has been applied for the research project of printable electronics. Utilization of printable electronics techniques requires a new kind of multidisciplinary competence base. Commercialization of the disruptive technology requires strong commitment also from academy. It is not an easy task to develop the results of basic research projects into commercially viable industrial solutions in an accelerated schedule. An industry-academy collaborative working mode enables to move the role of universities towards improving industry-related education in some selected disciplines. [10, 12]

Small research groups can benefit considerably from an industry-academy collaborative framework. For such groups, it is difficult to compete with international top institutes in research volume. According to our experience, collaboration with international industrial partners helps the research group in networking with leading international research institute and industrial partners. There is an ongoing industrial structural change in the industrial world. Also the

electronics industry is at the edge of changes. Well-focused industry-academy collaboration is very productive way to build new business opportunities for the local industry. [12, 13]

III. CASE

The electronics industry is passing through a transitional period with competition intensifying as never before. Many long-serving technologies are no longer efficient enough to fulfill ever-growing expectations of future customers. New technologies are needed. Long-term and well-focused research plan and productive operation is needed that the small research group can build recognized role in global community. An industry-academy collaborative framework has been in the research strategy of TUT Institute of Electronics for several years. An open environment for inter-organizational research work intensifying a competence creation takes time to grow. At the early phase, the form of cooperation was project-based. There were traditional industry-academy research projects targeting the development of electronics miniaturization technologies, mainly a direct chip attach method, and required supporting competences, like modeling, system design, and system reliability. Also, conductive adhesives, Three-dimensional Molded Interconnection Device (3D MID) technologies, system integration, and flexible substrates were studied. All these technologies were needed to build the first generation's electronics module that is presented in Figure 3. [6-11]

Today, the electronics manufacturing is based on handling lots of individually packaged ICs and discrete components. The following figures illustrate a technological path from current mainstream Surface Mount Technology, Figure 2, to the integrated electronics solution, module Figure 3. The BlueTooth headset module was manufactured using fine pitch SMT, whereas mechanics part was used as routing substrate instead of Printed Wiring Board. [6, 9]

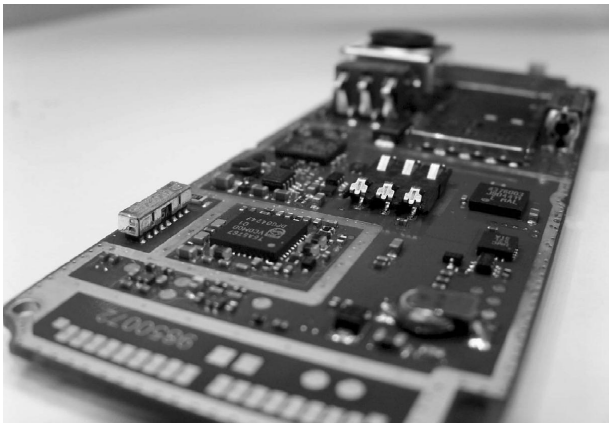

Figure 2: The current electronics assembly

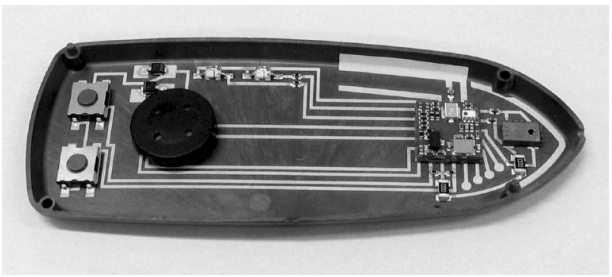

Figure 3: The electronics module attached on cover mechanics plated routing

Each technology requires specific competences that made easier to adopt new technology solutions. Integration and miniaturization benefit modeling, system design and reliability competences. The next phase of integration, printable electronics, required nano-technology competences. Additive printable electronics techniques are based on material innovations in the field of nano-material science, and existing process methods tailored for these special materials. Typical benefits of such technologies are reduced cost, increased performance/ weight/size ratio, shorter manufacturing cycle time, and improved functionality compared with traditional technologies or established process flows. [7, 10]

Novel printing method enables high integration level and simultaneous fine pitch routing and interconnecting. Achieving this close cooperation with equipment and ink manufactures was required. Furthermore, modeling and simulation

were needed to be tailored for the new technology. The printing method resulting highly integrated module has presented in Figure 4.

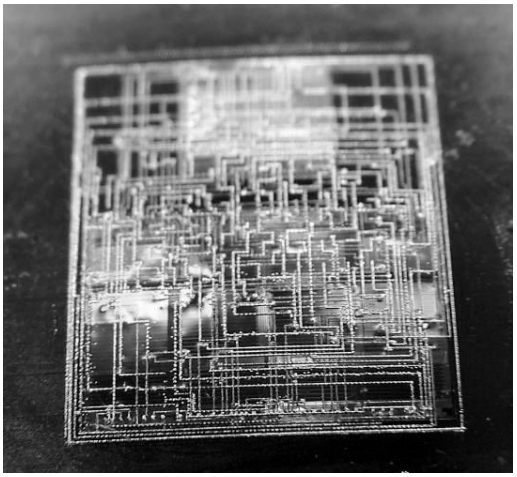

Figure 4: The electronics module produced by printing process.

Utilization of printable electronics techniques requires a multidisciplinary approach, because a scientific phenomenon behind these additive technologies is the complex combination of fundamental physics and chemistry. In addition, these technologies are changing established value networks and supply chains. Industry-academy collaboration combined with an industrial R&D network constitutes a profitable framework to explore the various opportunities these integrative technologies may provide. In addition, future value networks and supply chains can be forged simultaneously. [7, 10]

IV. COLLABORATION IN PRACTICE

Technology development is human-intensive work and the choices that must be made are always time-, context-, and people-related. A long-term fruitful relationship can be dreamed up by selecting right kind of managers and researchers for the interface of collaborating organizations. From the management point of view, such a collaborative framework is very challenging, because managers are working in a system composed of various kinds of agreements, classified and open information, intellectual property rights (IPR) sharing challenges, resource allocation decisions, and so on. In this case, managerial methods to strengthen the participants' commitment to the common targets would be virtual team rooms and common databases, inter-organizational weekly or monthly meetings, common incentive bonus system, seminars, and jointly written articles and innovation reports [5].

According to our definition, a successful a multidisciplinary inter-organizational team should be managed so that it has:

1. International competitiveness to meet the global standards
2. Communicative, trustful, safe, and open organizational culture with well-defined practices
3. Dynamic organization which allows flexible and immediate action within cooperative framework with outsides research partners
4. Common and well-defined targets
5. Right persons in right positions

Every multilateral process has many sides, many expectations (even if slightly different), and many cultures to be joined (at least in some level). In this framework's inter-organizational case projects, it took over six months to create relaxed atmosphere within the inter-organizational research teams [7, 10, 12]

According to our findings, personnel mobility can intensify and open up cooperation. The persons with capability to understand and function on both sides of industry-academy framework began working more closely with their partners to promote cooperation. On the other hand, the industrial partner found it important to bring the industry's point of view to the research work, learn academic culture, and create person-to-person relationships between industry and academia [1,,4, 9].

We learned that successful industry-academy collaboration is more than cooperation between

research teams. Company management and university administration should agree on policy definitions such as the framework agreement on IPR policy to smoothen the negotiations for starting practical research. At least inter-organizational negotiations should be conducted to define the collaboration target.

Our findings indicate that the main challenges in inter-organizational research cooperation are the building of a trustful, collaborative, and communicative research environment and the definition of common targets for all in the consortium to feel they have gained something. These basics will help build a strong will for cooperation to sustain and support development projects in difficult times.

V. Conclusions and Future Remarks

In the electronics industry, product creation cycles are shortening, and consumers are becoming more aware of technological possibilities, environmental issues, or newest gismos available. The established technologies will soon be outdated, and new ones are sorely needed. The future technologies will be based increasingly on inventions from several branches of science. Printable electronics techniques offer one option for future products with benefits such as reduced cost, increased performance/weight/size ratio, shorter manufacturing cycle time, and improved functionality. However, these techniques will change existing value networks, supply chains, product architectures, design guidelines, research and development processes, and so on. Furthermore, to decentralize risks and costs, they must be developed and produced within networks.

A possible way to branch out one's competence base and to accelerate knowledge transfer from publicly funded research into the industry is solid, confidential, and well-focused industry-academy collaboration enabling role differentiation between partners. To achieve its targets, it should be based on equality, respect, and trust, with no one partner overriding the others and undermining cooperation.

The global structural change in the electronics industry forces countries to redefine their means to strengthen their competitiveness in this changing environment. The main social benefit of an industry-academy collaborative framework is the development of a local industry. The collaborative framework helps the local accumulation of experts who are motivated to push through the commercialization of a new technology. To implement a new technology, we need a knowledge-intensive approach, which emphasizes the role of universities in the process.

We found that research groups from small countries can gain valuable support from their international industrial partners in networking with international top universities and companies in the field. Furthermore, companies can access critical competencies necessary for exploiting new technologies.

A fruitful new technology development requires multi-skilled professionals to manage operations, well-defined processes, time, money, expert personnel with right attitude, and an environment supportive of innovations. A key choice in setting up an open and innovative research environment is to select right persons for the interface of organizations.

The main result of this study is that to develop a new integrative technology, efficient industry-academia collaboration combined with an industrial R&D network helps accumulate knowledge and accelerate the commercialization of a technology. However, managing a collaborative framework demands skills to respond to challenges such as communication challenges, intellectual property sharing, negations of various agreements, selection of the right persons for cooperation projects, differences in opinion of common targets, and discussions on sharing costs and benefits.

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