Semiconductor Innovation Ecosystem-Learnings for India

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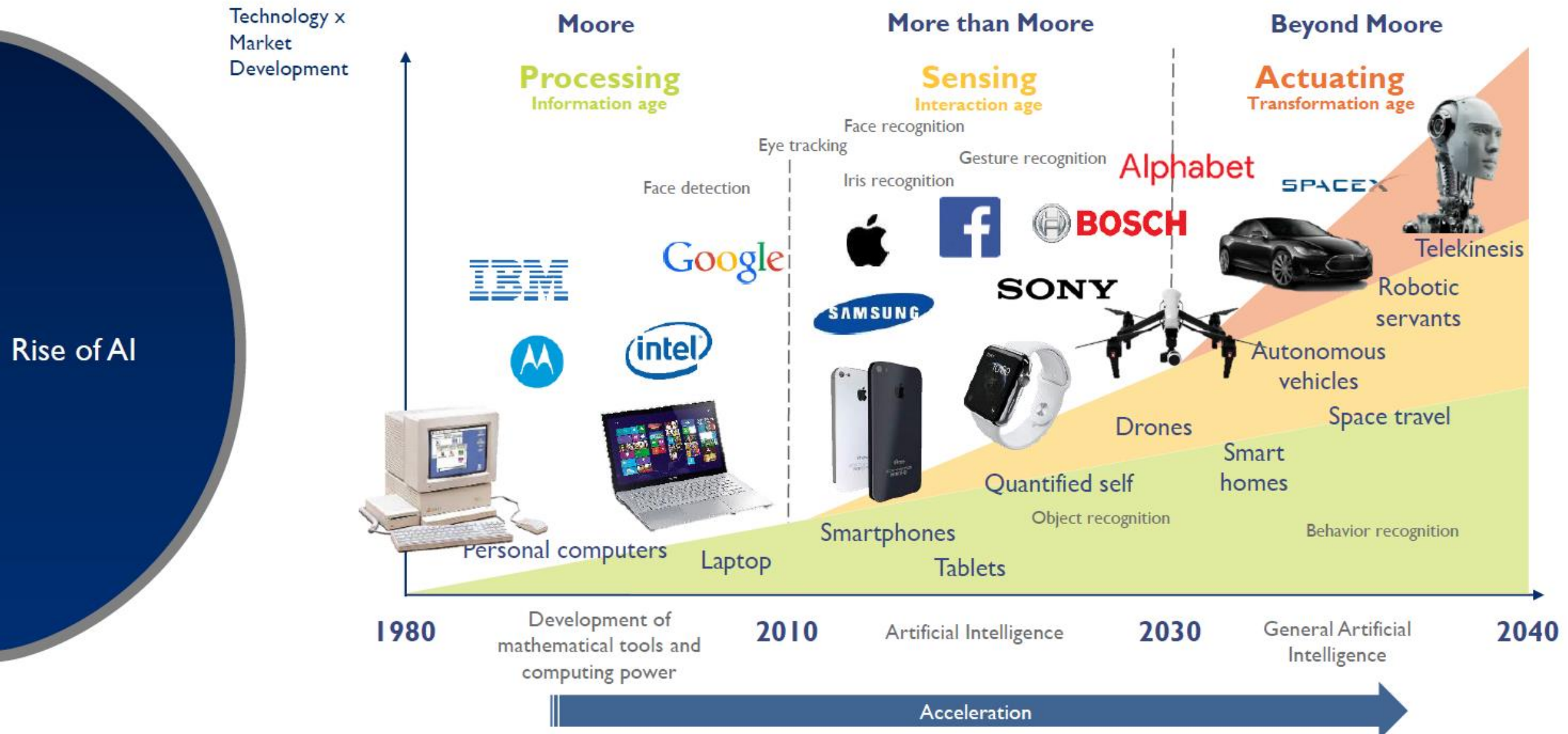
Paper submitted to Ministry of Electronics & IT, Sept 2020

Semiconductor Innovation Ecosystems- Learnings for India

Content Flow

- Semiconductors, India Aspiration & Semiconductor Innovation ecosystem
- Highlights of the Literature Survey
- IMEC- the world-leader in semiconductor nanotech R&D
- Learnings from other Innovations
- Learnings & Discussion

Global Trends are accelerating electronics as a meta technology...



Rise of AI

Semiconductor growth is exponential…& Semiconductor innovation models have evolved…

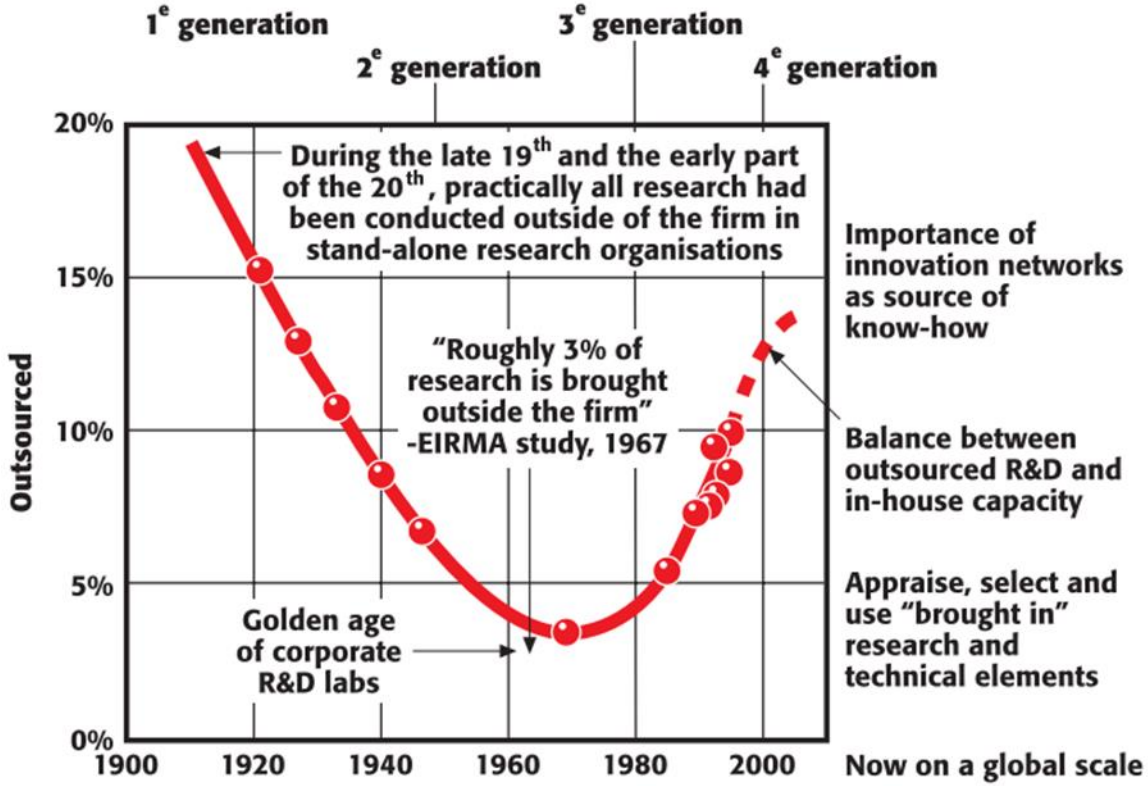


Figure: Changing patterns of R&D outsourcing (Collins, 2006)

- Semiconductor innovation is more broad-based spanning materials, processes, equipment from front-end to back-end of semiconductor manufacturing
- Requiring collaboration networks across the ecosystem…
- …and getting into cross-functional, cross-industry innovation

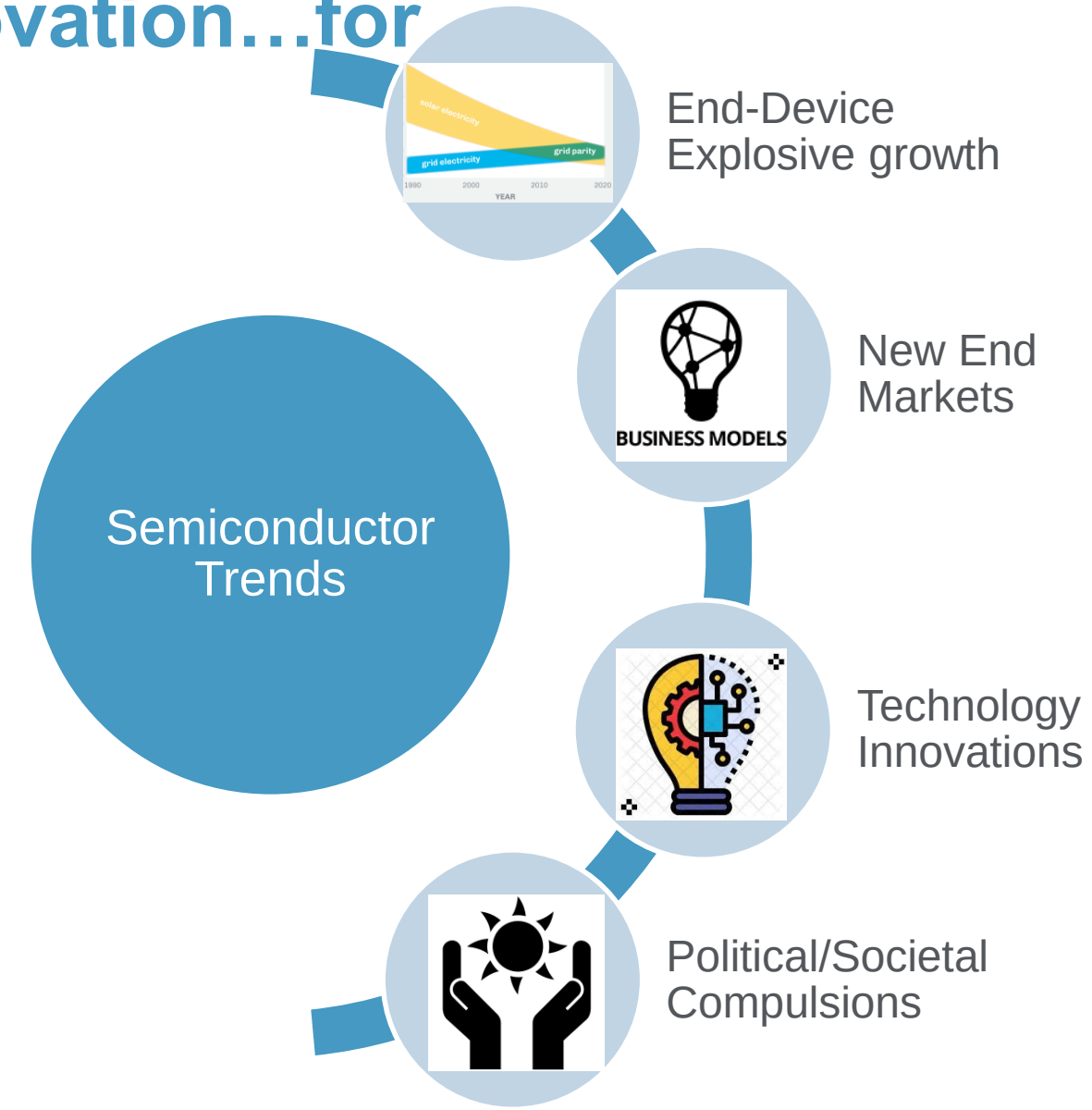
Research Need…

- After missing the semiconductor wave in the last decades, India is seeking to enable its semiconductor industry. What is the intervention that can enable its semiconductor innovation ecosystem?

…& ITS SIGNIFICANCE

- Learnings from the literature review can help in identifying possible paths to enable the semiconductor innovation ecosystem for an aspiring nation
- Understanding the triggers can reshape government and regulatory policies
- Evolve newer business models

Key global trends supporting growth of semiconductor innovation…for

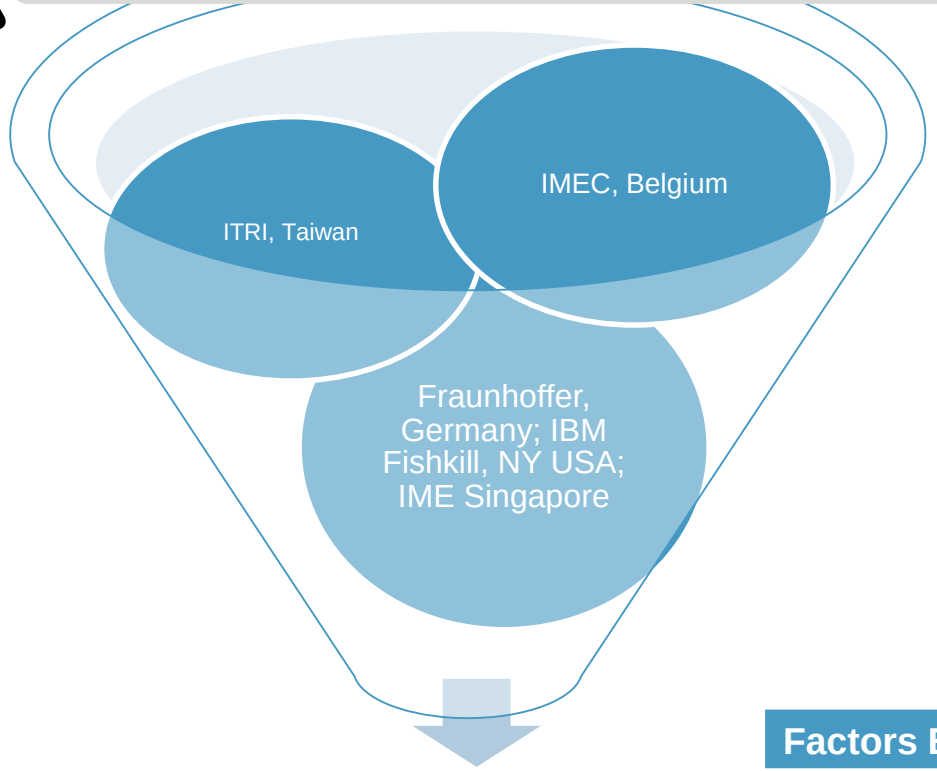


- …But the key enabler for India will be industry adoption of the new technology from India

- And the key disabler – the human & ecosystem resistance to change

Learnings Extracted from Literature Review

Semiconductor Innovation Models in Literature



IMEC, ITRI

Innovation Ecosystem Gaps Identified

- Collaboration Network
- Sector Focus
- Infrastructure
- IP creation, sharing Models
- R&D service Demand Management
- End Demand Management

Factors Extracted	Other Variables
• Markets targeted	• **Maturity of the Institution**
• Technology Focus	• **Geo-politics**
• Background IP	• **Funding support**
• IP Sharing mechanisms	• **Serendipity**
• Collaboration networks	• **Technology-to-mkt programs**

Global Semiconductor Innovation Ecosystems

IMEC Belgium

ITRI, Taiwan

Others (IBM Fishkill, USA; IME Singapore)

Leading Public Innovation Agencies- an Overview

	FhG	IMEC	ITRI
Legal Struchure	Non Profit organization	Non Profit organization	Non Profit organization
Year of Establishment	1949	1984	1973
Number of Employees	27988	4505	6195
Total Revenue (Million US$)	3174	736	837
External Funding (Contract research)	2639.25	estimated 588	326
Ratio of External Funds	83%	~80%	39%

NT$->US $ conversion at .03414

Euro to US$ conversion at 1.15

References: Annual Reports of respective agencies/website URLs cited/ IMEC External funding data based on expert inputs (Fraunhoffer, 2019; "IMEC Wiki," 2019; ITRI, 2019)

IME, Singapore and IBM Fishkill, NY, USA are other more recent examples of semiconductor innovation ecosystems

- IMEC has emerged as a dominant innovation fountainhead for semiconductors in the recent years followed by ITRI

- Learnings from their open innovation model covers:
  - Industry Collaboration Models
  - IP sharing rules followed
  - Role of the Government
  - Go-to-Market strategies

Case Study- IMEC, Belgium (1. Technology Focus)

- Open Innovation Ecosystem focused on Semiconductor Sector – doing R&D on nano-electronics, with the aim to provide solutions to technical problems faced by industry
- Achieved status as a global research base, metrics include:
  - Proceeds from sponsored research, Sponsored Project Revenue, # of Articles published, # of invited papers published by IMEC researchers
  - Education: # of PhDs obtained, # of joint projects
  - Contributions to Industry: # of spin off companies in a year; Contribution to growth of local capacity (people); # of industry related exchanges

- Research Fields cover:
  - More Moore
    - CMOS related technology innovation, driving technology roadmaps in semiconductors
  - More-than-Moore (CMORE)
    - MEMS, Analog Sensors, power and telecom electronics; 3D packaging
  - Beyond Moore
    - Wide-band semiconductors, GaN / SiC technologies; Photonics etc
  - Semiconductors in other Sectors
    - Recent times, IMEC has looked at cross-fertilization of talent from different sectors (ex.MedTech) to drive semiconductor innovation to different heights

Case Study- IMEC, Belgium (2. Role of Government)

- Consolidation of fragmented University resources under Interuniversity Microelectronics Centre, 1984
- 2009-2018, Flemish Govt gave an endowment of € 0.63 billion
- IMEC added value of € 4.91 billion in Flanders and a fiscal return of € 2.59 billion to state & federal authorities
- IMEC's collaboration w/ international companies generates an annual influx of fresh foreign capital of more than € 350 million to Flanders
- KEY Msg: IMEC contributes significantly to the economic growth of Flemish economy

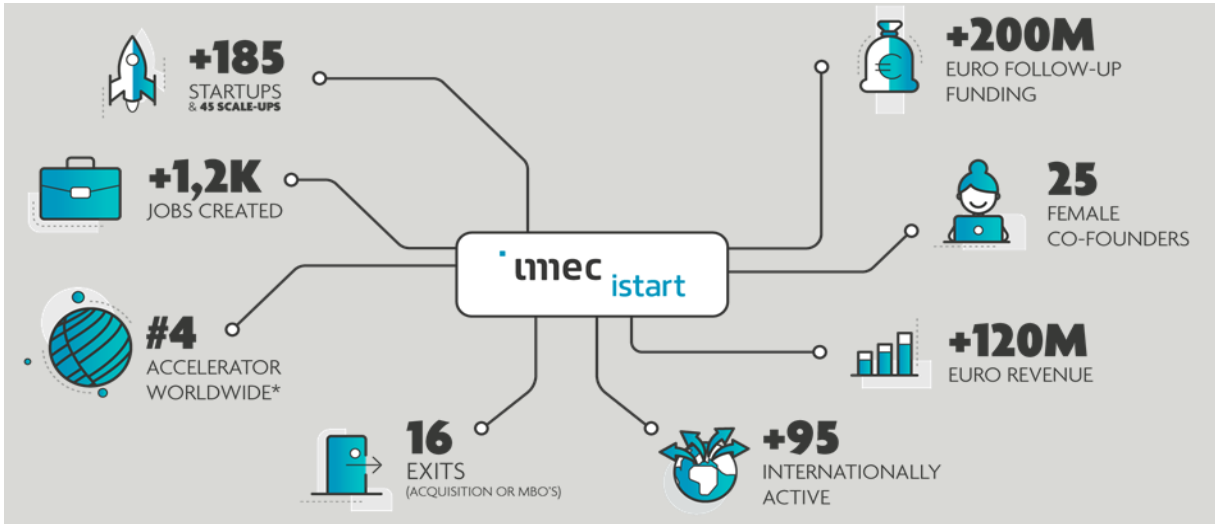
- Run as a business. Clear defined rules of engagement for collaboration, IP sharing and technology go-to-market with appropriate enabling flexibility.
- Approx 75-80% of project funding is from external sponsors
- Business development division has a staffing in Belgium and Overseas. Technically competent staff drive the marketing role
- Government intervention in IMEC operations is nominal – the not-for-profit organization is lead by a board of professional leaders
- Evaluation done every 5 years since 1996. Based on evaluation, a basic contract concluded with Flander's Govt for next 5 years , for which grant is provided.

Case Study: IMEC (3. Industry Programs that commercialize)

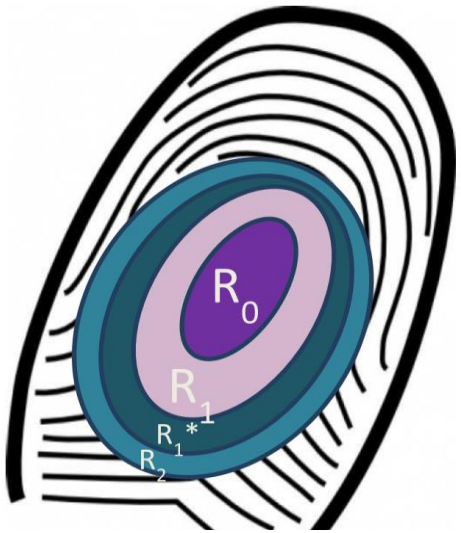
- IMEC Industry Affiliation Program
  - Multi-client project development envisaged
  - Joint use of development costs, risks, development capabilities & IP
  - Brought a new business model for accumulating and using IP for IP creation
- Operating principle is being responsible partners to IP creation so that public funds are gainfully utilized and IP utilization is maximised
- Creates a cycle of expanding patent/ knowledge base
- Has who's who of semiconductor industry in its IIAP membership
- Huge investment in semi R&D, mitigated by an effective IAP

Idea discovery-.Incubation-Actualization enabled by :

- Imec-istart (2011)
  - Ranked in top 5 Global University linked Tech Accelerator & # 1 in Europe
- Imec.xpand
  - Early stage growth fund to turn hardware driven nanotech innovation into commercial success (focus on ventures in which imec's IP, tech/expertise are leveraged)
  - Initial financial injection of € 50,000 pre-seed fund



Case Study: IMEC (4. Clear IP Sharing rules)



Background IP:

Developed prior or in parallel with contract; limited in content and by time

Foreground IP:

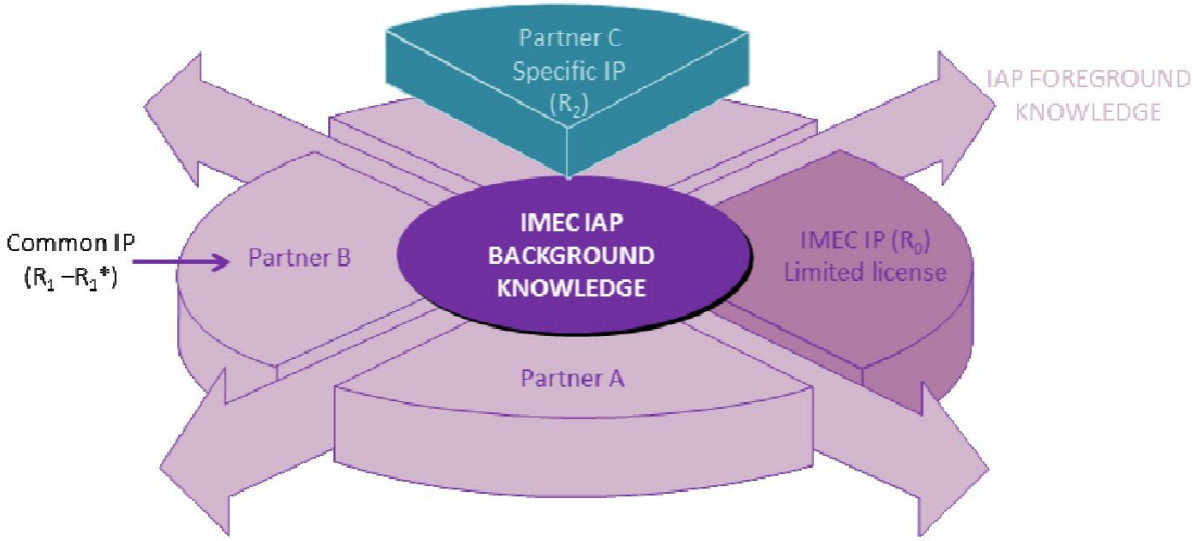
Developed within contract

R_0: Solely owned by IMEC, no right to partner

R_1: Jointly owned by IMEC & Partner, no restrictions

R_1 : Jointly owned by IMEC, restrictions

R_2:Solely owned by partners, no rights to IMEC



- Creating value from IP @ IMEC (Helleputte & Overstraeten, 1993)
- Fundamental principle: IP is owned by person/entity who creates it

Fig. IAP IP Fingerprints(Roijakkers, Leten, Vanhaverbeke, Clerix, & Van Helleputte, 2013)

Observations from global Semi Innovation Ecosystems

ITRI, Taiwan	IBM Fishkill, NY, USA	IME, Singapore
• Conceived in Taiwan in 1970s, evolved Taiwanese Electronics ecosystem from Hsinchu Tech Park • Strong focus on industry commercialization • Leverages its 'alumni' base of incubated companies • Integrates cohesively, coherently research, education and idea-discovery-to-commercialization – something that most other countries struggle with • It has evolved from tech import phase in 70s to tech knowledge bridge in 80s to industry fountainhead position by late 90s & currently developing inter-disciplinary IP linkages	• Private sector led innovation ecosystem • Both have basic background-foreground IP sharing models • However, IMEC model permits evolving customized version of foreground IP for IIA Partners • And IMEC is seen as a commercially neutral party • With IMEC having built a strong reserve of background IP that it is able to leverage in its momentum to capture the best IIA partners & create a stronger launchpad for commercial success of resulting IP. • IMEC's initiative for cross-fertilizing opportunities between life-sciences & semiconductors is path-breaking	Conceived under Singapore's Advanced Science, Technology and Research Program (A*Star), Institute of Micro Electronics - Leverages its version of Industry Affiliate program to get huge infrastructure investments for R&D in advanced packaging - Is niche -positioned as the regional go-to center for heterogenous integration of chips, advanced packaging, IOT at edge, Sensors and medtech

Learnings & Discussions

Research Contribution

Limitations of this research

Recommendations for future studies

Learnings for India/Other Markets

- IMEC, ITRI, IME are mature Semiconductor Research institutions with open innovation ecosystems - with strong background IP, talent capacity and infrastructure

- Given the well-established players, a new greenfield project will require to define a clear target positioning of its R&D Program. What are its proposed R&D services? How will it find its markets? Why it will be preferred over well-established players? …are some of the questions that must be answered at the start of the project…

Learnings for Practice

#1 Sustainable Innovation Positions

- Following end-sectors offer sustainable innovation positions for an aspiring nation like India
  - Med-tech (Life-Sciences, Bio-tech, Healthcare)
  - Agri-tech
  - Fin-tech
- (These sectors are relevant for India as well as enabled for domestic operations by security considerations within rules of ITA1)

#2 Sustainable Technology Innovation

- Since overall India's tech position in semiconductors is weak, it is unlikely to have a traction in more-of-moore technologies that drive towards lower feature size devices
- However, prospective innovation opportunities in More-than-Moore technologies can be mined by cross-fertilizing with the suggested end-markets and leveraging its vast people resources

Learnings for Practice

#3 Sustainable Tech Innovation (3)

- There is also a strong opportunity in Beyond-Moore technologies by leveraging the inflexion in compound semiconductor devices and market opportunities created in power electronics, RF, Telecom (5G & beyond) networks

#4 Sustainable Tech Innovation (4)

- Advent of heterogenous integration of chips creates a new era of advanced system-in-package.
- A careful capacity/competence building here will enable innovation flexibility for India

Learnings for Practice

#5 Creation of India chip portfolio

- India has to evolve a strong demand side management of its chip designs/proto-types to pull the interest of its target commercial fabs
- It must have a national fabless design mission that manages the India chip portfolio wrt a carefully drawn and constantly evolving roadmap of target applications/ functionalities of end-devices

#6 New Era Policies

- There has to be a careful demand management thru appropriate policy and industry enabling marketing programs
- These policies have to be WTO ITA1 compliant and yet enable demand aggregation that leverage India strengths (vast healthcare, agri-base, fintech data) to meet the needs of India and global communities.

Learnings for Practise

#7 IP Management Ecosystem

- There is a strong need to couple innovation with strong IP management laws(Fisher & Oberholzer-Gee, 2013).
- While to some extent corporate management can mitigate weak (IP protection, true innovation can be enabled when the economy is seen as a low-risk economy(Minyuan)

#8 Globally integrated Innovation

- Open Innovation Ecosystem with flexibility of approach and competitive position will be critical to realizing this aspect of the innovation ecosystem.
- Half-hearted approach will not work. Bold steps are the way to go – else it is best not to start!

Supporting Papers

Other Works/Industry papers

Jump-starting Electronics – recommendations for National Policy of Electronics 2.0, 2018 (as Chairperson, IESA)

Indian Semiconductor Demand – an analysis from a fab loading perspective (IESA) 2017

DPR for a National Semiconductor R&D Lab, Dec-2020 (as member of working group, PSA-IIT B, Govt of India)

Electronics Component Task Force Report, 2020 (as chair of semiconductors sector, Electronic Industries Association of India)

Pathways to success – building semiconductor people capacity in India, 2014 (AM India industry white-paper)

Pathways to sustainability – India's options for semiconductors, 2015 (AM India industry white-paper)

Limitations of this Study

- Literature Review
  - Leverages published content on the key global semiconductor R&D centers from their websites
  - And from peer-approved journals
- Longitudinal analysis
  - Study does not take into account the time horizon in which the global ecosystem matured and hypothesizes cross-fertilization opportunities in a brain-storming mode
- Lack of Indian Semiconductor Ecosystem
  - Results could be distorted because of the absence of a mainstream Indian fab and its related supply-chain
- Findings of the study are limited to and cannot be automatically generalized to other nationalities because of potential cultural, socio-economic and policy/ political priorities and context differences

Recommendations for future studies

- Geographical Context Extensions in India/ abroad
- Longitudinal Studies
- Demand & Impact Modeling
- Technology cross-fertilization models to be evolved

India's (academic) rise in nano-electronics!

From zero publications in 2011 to a world-class performance in 2016!

(Ganguly, et al, 2021)

Semiconductors & their innovation ecosystems will clearly be a very promising and fertile ground for academic studies in the quest to make this vision a reality!

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