Study Course Entrepreneurship

Unit 2: Research in Start-ups

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http://impact.uni-bremen.de/

What is a start-up?

- A business with a business plan that features
  - Technical or business method invention(s), and
  - Expected quick adoption resulting in fast rise in revenue and valuation (more than doubling every year is OK).

- Investors like to see hockey-stick-shaped revenue

Basing a start-up on scientific novelty

- The objective of scientific discovery or invention is to provide knowledge or technology to general public.
- The objective of a start-up company is to implement the novelty to make product that will be used/purchased by the general public and so the company will make money while providing this novelty to the society.

- Most of the time, scientific discovery or fundamental technology development happens at a university.

Two options in technology transfer

- **A – Ideal approach**:
  - Scientific development has been completed,
  - Technology has been patented by an university and licenced to the start-up;
  - Start-up focuses on developing a product (engineering development).

- **B – Less than perfect / risky**:
  - Scientific development has not been completed,
  - Start-up is hoping to create new IP and fully de-risk the technology.

Why would one do B?

A offers

- Reduced technology risk, but not completely and loss of opportunity time.

B offers

- Faster time to market, because one can focus on developing a product sooner and creating one own's IP.
- High risk of underestimating the diffculty of bringing technology to commerciallization.

- How do you know when is the technology ready?

Technology readiness

Level	Description
1	Basic principles observed
2	Technology concept formulated
3	Experimental proof of concept
4	Technology validated in lab
5	Technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
6	Technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
7	System prototype demonstration in operational environment
8	System complete and qualified
9	Actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

How start-ups start?

University spin-off:

- Research results look like they could be used to create commercially interesting products,
- Intellectual property is protected,
- The professor with students forms a new company and the company licenses the intellectual property from the University,
- Funding the company (boot-straping, angel investors or venture capitalists).
- Offices are rented in the proximity of the university or university resources are used and paid for.

How start-ups start?

Starting from industry:

- Engineers/managers from one or more companies meet and form a new company.

Spin-off from a large company:

- Large company wants to differentiate itself, lower the risk so they spin-out a division.

Characteristics of a start-up company

- Small group of people trying to solve and important problem using a non-conventional approach believing that their company will conquer the world.
- Working long hours and weekends is not uncommon.
- The contribution and responsibility of each person is obvious (this is in contrast with large companies).
- The employees are excited about their work and proud of their company.
- All employees are owners of company stock.

Characteristics of a start-up company

- Probability of failure is ever-present regardless of whether fund have been raised recently.
- Having enough cash for 6 months of operation constitutes “job security”.

Financing the company

- It is of critical importance to connect the proposed technology/product with the **right** type of investor:
  - If you expect long terms development, it is more efficient to use government grants or keep the development within and university.
  - If the product is well defined and comprises low technology risk, going after private investment is a better approach („*venture capital*"). out.

Financing the company

- Investors want to liquidate their ownership on a public stock exchange (IPO) or by selling the company:
  - Time to liquidity is 5-7 years: there is no time for scientific development and technology risk.
  - If you want to be independent and remain your own boss, you should not take an investment.
  - There are other ways, but they are complex and do not always work out.

Financing sources

- Early phases (TRL 1 to 3):
  - Private resources (*bootstrap, self-funding*)
  - "*friends & family*"
  - angel investors
- Government grants (TRL 1 to3),
- Venture Capital,
  - Product development and early production phase;
- Industrial partners (strategic investment)
  - A large corporation is interested in your product;
- Investment bankers, merger's & acquisition bankers:
  - Late stage financing, production, preparations for IPO or selling the company.

Commercialization risks

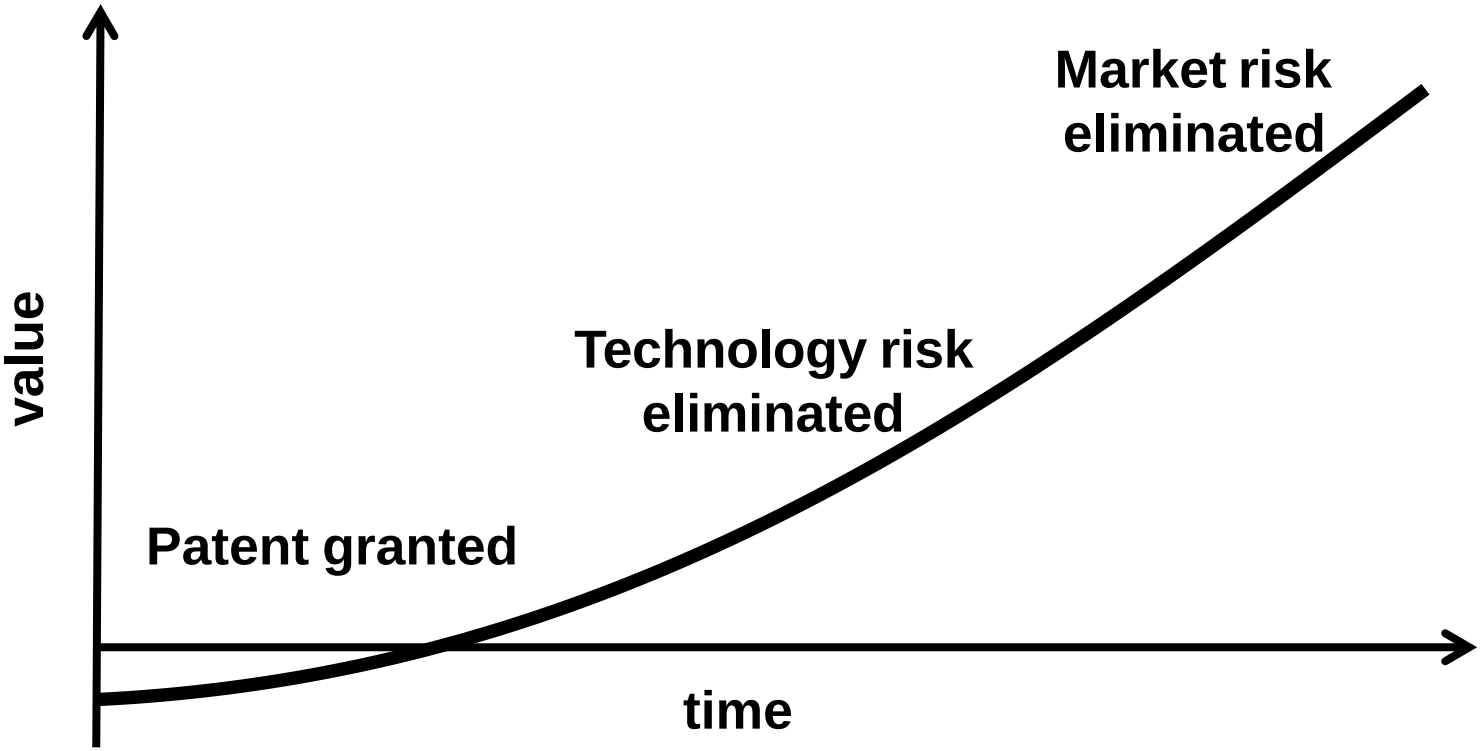
Start-up company identifies a market for a product, raises capital and invests time to develop product.

What determines whether the venture will be successful?

- **Technology risk**: will product work as planned?
- **Market risk** (at the time when the product is complete),
  - Will there be same demand? ⍰ Timing risk
  - Alternative solution? ⍰ Competing technology
  - Competitor with similar technology? ⍰ Monopoly
  - Product infringes on some IP? ⍰ Freedom to Operate?

One needs lots of luck to succeed

Value of intellectual property



Most common failure causes

Management:

- Engineers with no experience believe that they are good managers, marketing, sales, or manufacturing professionals.
- Product not ready for manufacturing
- Feature creep causes product never to enter manufacturing
- Lack of manufacturing discipline to finish product and take it to market.
- Lack of experience in managing cash
- Investor has different agenda

Bad luck

- You've done everything right and all you needed is a little bit of luck

Venture capital

- **Partnership that manages money of limited partners** who want high return on investment.
- Limited partners are private or industrial investors.
- Fund value is $50M - $200M, and expected return is 10X – 100X in 3-7 years.

This means:

- Attacking a large market ~$1000 M,
- Seek innovations and technologies that will improve things an order of magnitude (10X) relative to status quo.
- Start-up in the phase where development is completed and product

Venture capitalists

- In more than 90% of companies funded, all of the investment is lost,
- Expected average return on investment is ~ 20% annually
- Annual operation expense ~ 2% of the fund.
- For each investment, one partner gets a seat on the board of directors; minimal investment ~ $3-5M.

Funding from customers

A client, large potential customer sees that at some point in the future it may want to commercialize a product based on this technology. The client may pay for some aspect of the development in form of *non-recurring expenses* (NRE) or an advance payment for some number of product units.

The amount ~ $100k+.

The client may ask for:

- to sell the product exclusively,
- limited license for intellectual property,
- *most favorite nation* terms

Two (extreme) types of start-ups

The innovation is based on an adaptation of existing technology:

- Development requires engineering,
- The market for the product is saturated (competing products),

→ Risk: **Difficult to sell product**

The innovation is based on new technology:

- If the idea is good, strong market demand exists,
- However, product development is difficult, it requires scientific development,

→ Risk: **Difficult to develop a manufacturable product.**

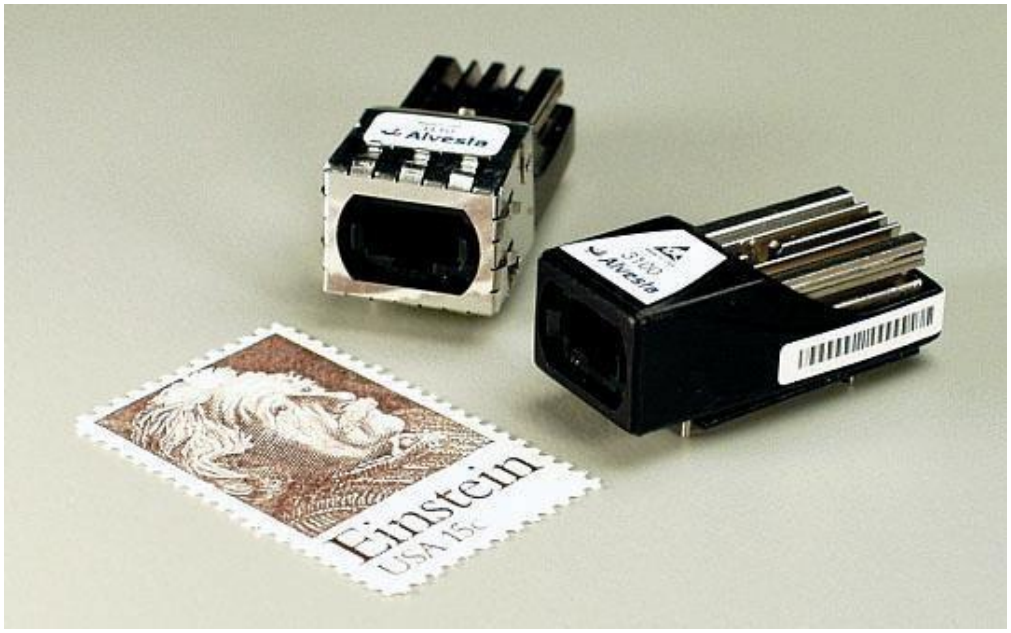
Case Study

Comparison between two start-ups from Silicon Valley 1999-2008

- **ALVESTA CORPORATION**
- **GROUP4 LABS, INC.**

Alvésta Corporation (1999.-2003)

Manufacturer of optical component and subsystems for short-distance interconnects



4 x 2.5 Gb/s full-duplex fiber-optic transceiver

- 10 Gb/s link capacity
- 300-meter reach
- uses standard 12-fiber ribbon
- standard MPO connector
- power dissipation 1W
- field-replacebale
- in production

Alvesta
Illuminating Fiber for the Future

Alvesta Corporation in brief

Product	Multi-channel fiber-optic transceivers for short-distance interconnects
What is unique?	Original design using known technology enables mass production; it was the only 10Gbps fiber-optic transceiver under < $300 at the time (2001)
Whose pain are we solving?	Reduces the cost and weight and increases throughput in central offices (network interconnects); replaces copper links.
Who are the primary customers?	Cisco Systems, Ciena, Lucent, Brightlink
Status of product at change of control	Fully qualified product (10,000 sold); TUV certification, reliability demonstrated, volume supply agreement with one customer
Intelectual property	5 patents issued and 4 patents pending
Financing	Seed funding: $250k (1999.), Series A=$3M (2000.), B=$17M (2000.), C=$12M (2001); sold to EMCORE Corp. (2002).

Alvesta
Illuminating Fiber for the Future

How did it start?

- Prof. John Bowers (UCSB) and DB write a business plan for long-wavelength (1300&1550 nm) vertical-cavity surface-emitting laser (optical communications; based on DB PhD work, TRL 3)
- Two more partners join in (Russel Bik & Albert Yuen).
- Option to license patents from University of California.
- **Can's raise money**. Perceived risk is too high, product too complex, and it required a foundry
- Albert proposes a change in product:
  make optical modules with
  VCSEL array
  (this was **not** rocket science)
- We raise $3M to make parallel optics
  after 9 months of no cash.

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Alvesta milestones

Alvesta
Illuminating Fiber for the Future

Founding employees

Alvesta incorporated

First patents filed

First working prototype

First customer shipment

First product release

*Design win - **Lucent***

1999: Apr, May, Jul, Sep, Nov
2000: Jan, Mar, May, Jul, Sep, Nov
2001: Jan, Mar, May

Hamarex Holdings

Series A $3M

Series B $17M

Design win - Customer *D*

intel
ENTERPRISE PARTNERS VentureCapital
FORCE10 NETWORKS
BrightLink NETWORKS

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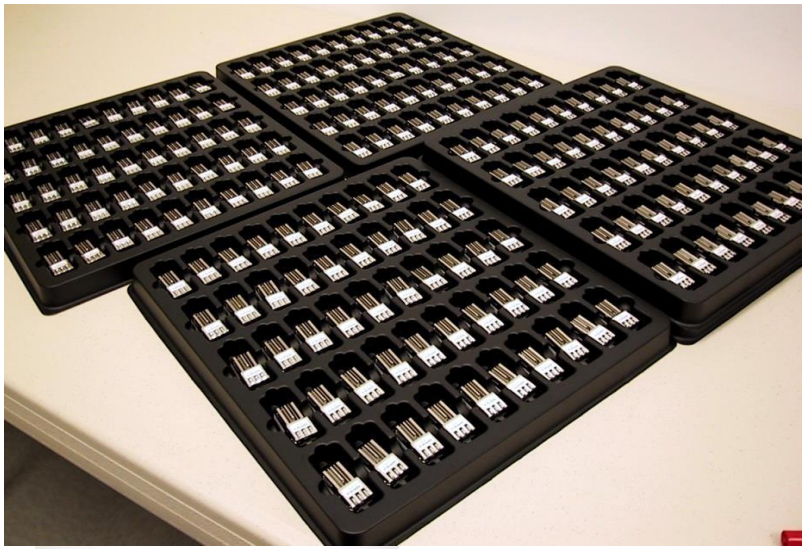
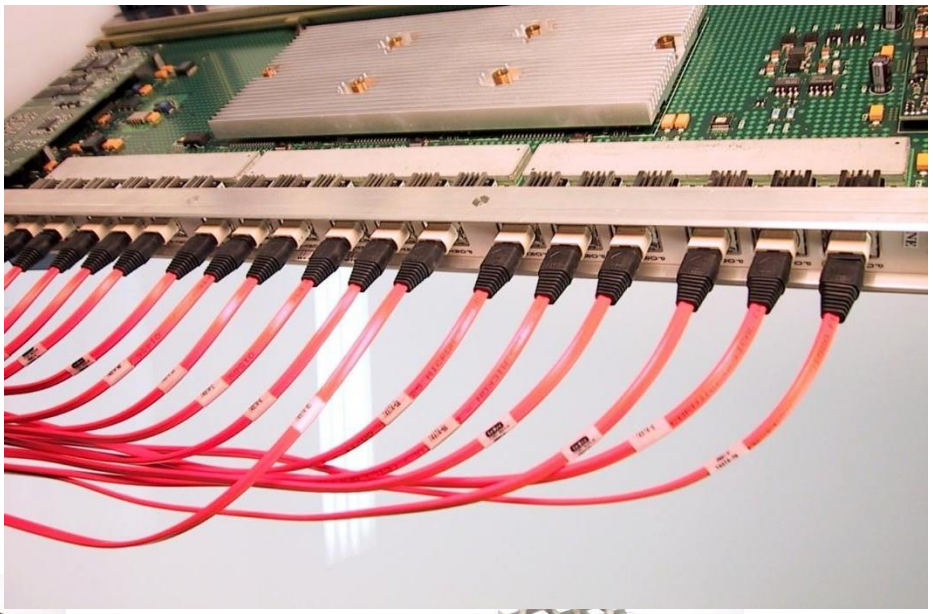
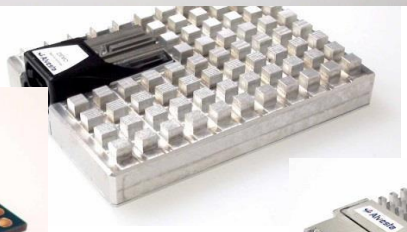
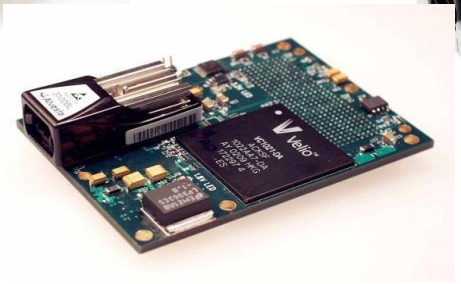
Optical modules in thousands









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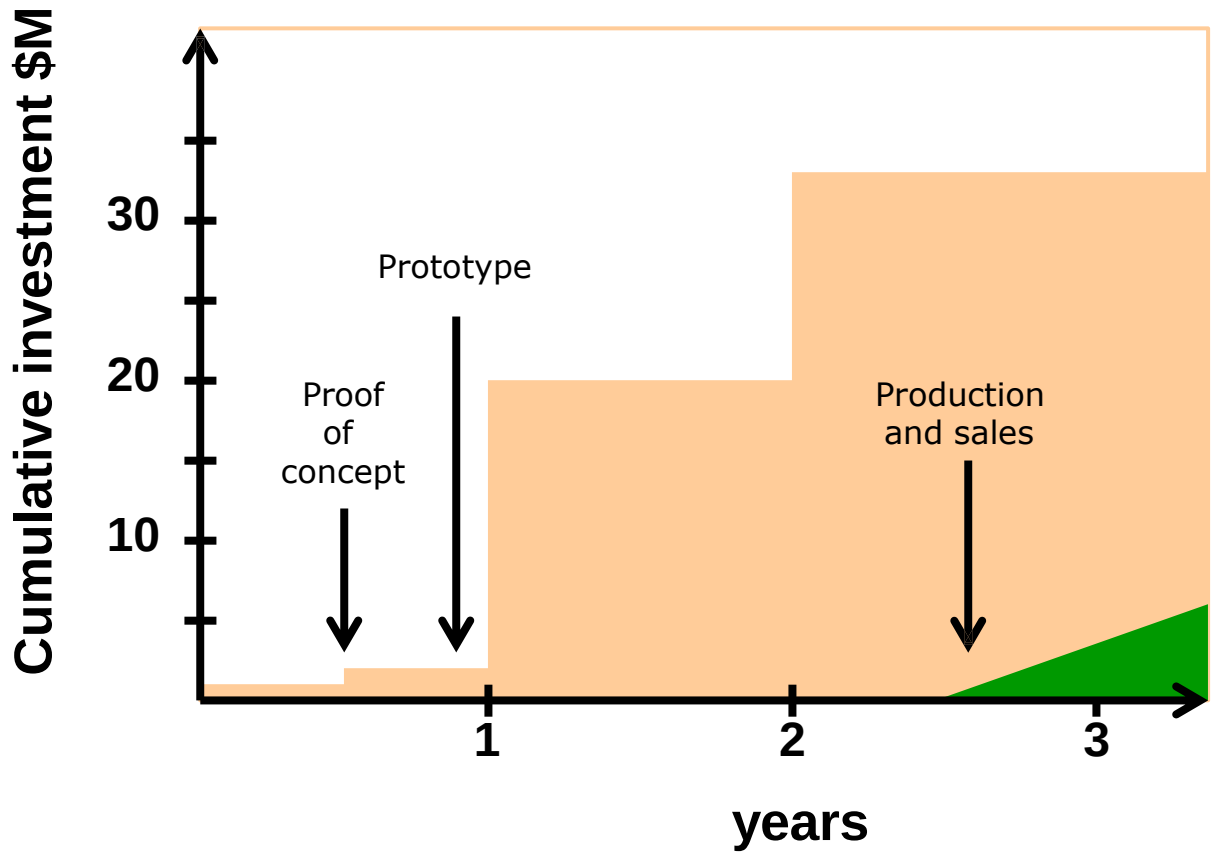
From idea to product



Alvesta
Illuminating Fiber for the Future

Alvesta aquisition 2002

CS COMPOUND SEMICONDUCTOR

Emcore Expands Fiber Portfolio By Buying Alvesta

17th December 2002

Emcore has bought key assets of Alvesta, best known for leading the development of four-channel parallel optical modules.

Emcore has acquired certain assets of privately held Alvesta Corporation, including product lines, inventory, and intellectual property. Alvesta of Sunnyvale, CA, is a developer of VCSEL-based parallel optical transceivers for fiber-optic communication networks.

GROUP4LABS™
AN EXTREME MATERIALS COMPANY

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GROUP4LABS™
AN EXTREME MATERIALS COMPANY

Product	Wafers with GaN epilayers on CVD diamond
What's special?	Diamond has the highest thermal conductivity known to man. Nobody in the world knew that it was possible to combine CVD diamond and GaN (they tried and failed).
Whose pain are we solving?	High-power RF amplifiers are inefficient and the cost of running them is high: so, reduction of cooling costs and reduction of equipment weight.
Who will buy and why?	Companies manufacturing RF communication systems, radar (*military industry*).
Status of product	Prototypes sold
Intelektual property	8 patents

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GROUP4 LABS PRODUCT

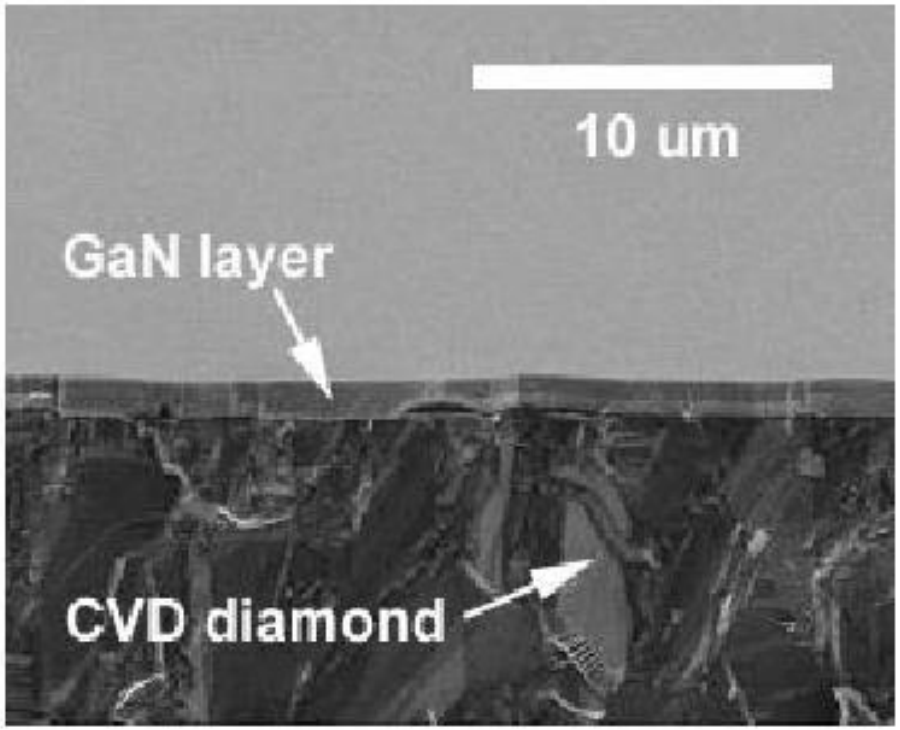

Figure 5 – SEM micrograph of GaN layer on top of CVD diamond

GROUP4LABS™
AN EXTREME MATERIALS COMPANY

Founders from 4 continents

Felix Ejeckam, Ph.D., Co-Founder & CEO

Prior to co-founding Group4 in 2003, Felix spent ten years in the management consultancy and photonics industries where he co-founded and led a [illegible]. He is an expert in photonics, and materials scie[illegible]es in electrical/computer engineering from Rice, a master's and doctorate in electrical engineering (photonics & materials science) from Cornell.

Africa

Daniel Francis, Ph.D., Co-Founder & Chief Technical Officer

Prior to joining Group4 in 2004, Dan spent ten years co-founding two VC-backed c[illegible]s industries. H[illegible]ence. He earned an undergraduate degree in physics from Oberlin, a doctorate in applied physics (photonics) from Stanford, and a post-doctoral appointment at Berkeley..

South America

Dubravko Babic, Ph.D., Vice President, Technology

Prior to joining Group4 in 2004, Dubravko spent twenty years in the electronics, photonics, materials science, and packaging industries working for renc[illegible]l building small companies. He is an expert i[illegible] and materials. He earned degrees in electrical engineering from the University of Zagreb, and a master's and doctorate in electrical engineering from UC Santa Barbara.

Europe

Firooz Faili, Ph.D., Vice President, Technology

Prior to joining Group4 in 2005, Firooz spent twenty years helping to build various small a[illegible]ies in the semiconductor industry. He is an e[illegible] science, electronics, and semiconductor man[illegible]nent. He earned degrees in chemical engineering from the Abadan Institute of Technology and San Jose State University, and a doctorate degree in chemical engineering from USC.

Asia

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Comparison

	Alvesta	Group4 Labs
Years in business	4	4
Product	Multichannel optical transceiver	Composite wafer
Critically needed for success	Profit – sufficient number of customers	Functional product
Highest number of employees	97	14
Scientific publications	0	7
Patenats	7	8
Total investment	$32M	$5M
Best year revenue/burn rate	$5M/$8M	$0/$1M

Technology survives

2008

GROUP4LABS™
AN EXTREME MATERIALS COMPANY

Element Six Acquires the Assets & Intellectual Property of Group4 Labs, Inc to Expand Portfolio of Synthetic Diamond Materials for the Semiconductor Industry

Synthetic Diamond Enables higher performance Gallium Nitride Devices, Resulting in Smaller, Faster and Higher Power Electronic Devices for Defense and Commercial Applications

2013

elementsix
a De Beers Group Company

2018

AKASH SYSTEMS

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Scientific development w/o academia

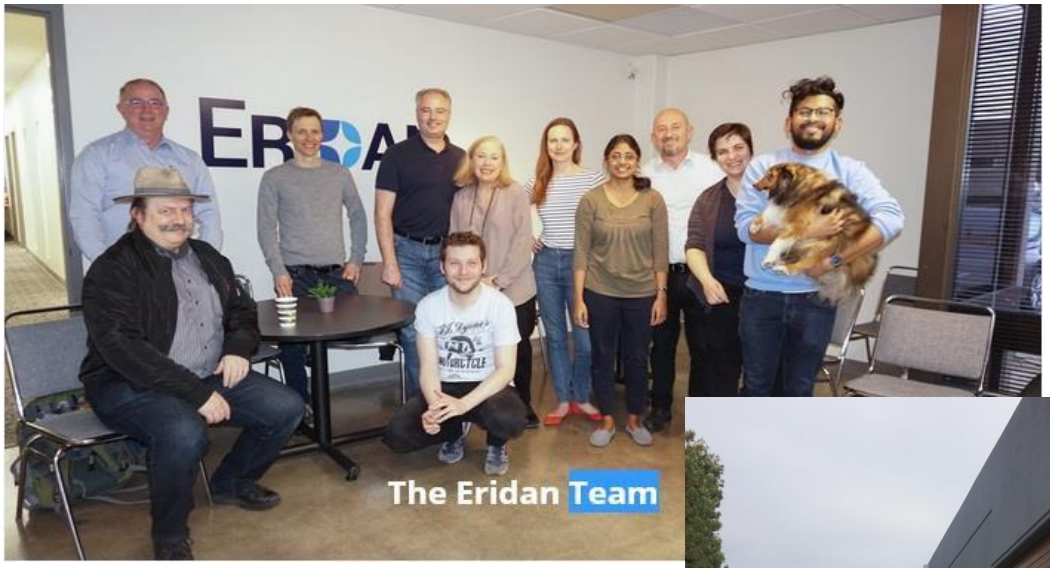
Scientific development occurs at universities or large corporations that have sufficient R&D budget.

However, if a start-up has been founded by individuals who were previously employed in the industry, then there is very little opportunity, time or funds to do research.

Majority of the activity is focused on product development activities.

This can be a risky proposition if the product is complex and is based on new technologies.

Eridan Communications, Inc.



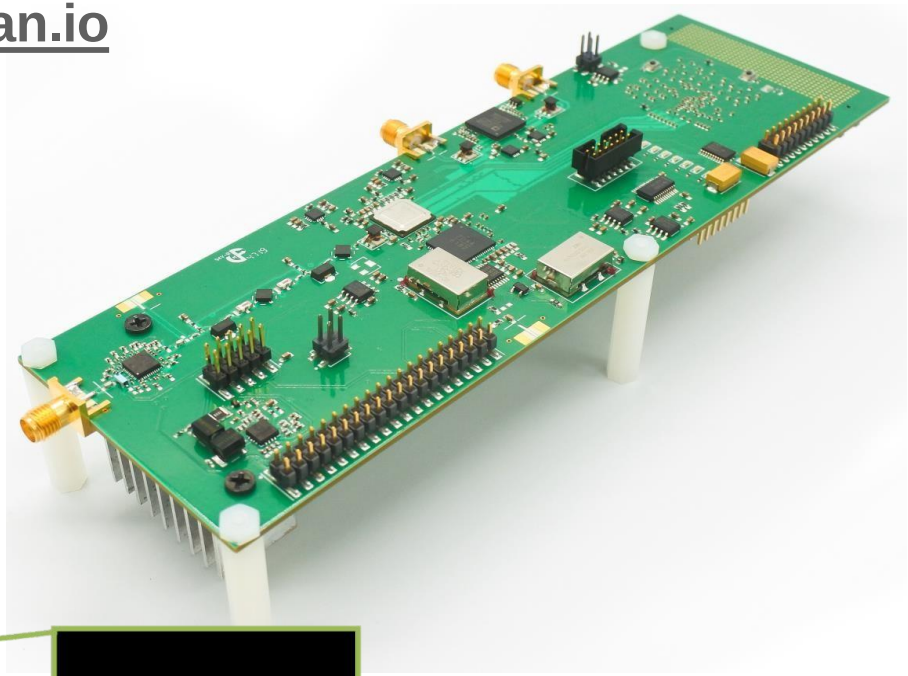
Founded in 2014

Product	Software defined transceiver
What's special?	Software defined carrier frequency 600-3700 MHz Energy efficiency 35% - 80% for all PAPR. High linearity
Whose pain are we solving?	Base station heat and inventory of different carrier frequencies.
Who will buy and why?	Base station manufacturers, military, first responders
Status of product	Selling development kits
Intelectual property	17 patents + pending

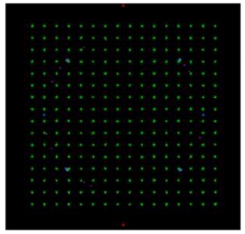
Software defined transceiver

Eridan MIRACLE Transceiver Development kit

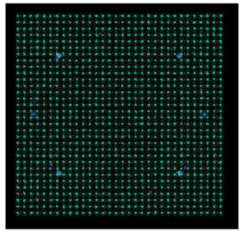
www.eridan.io



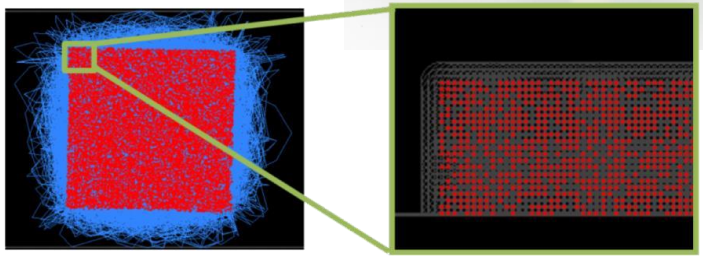
256 QAM
currently deployed



1024 QAM
in the 5G roadmap



16384 QAM
Eridan's current measurement limit



The mantra of product development

> The art of product development is the art of good enough
>
> — Douglas Kirkpatrick, Ph. D.
>
> *Chief Executive Officer,*
> *Eridan Communications, Inc.*

Conclusion…

Doing scientific research in a start-up:
if you have a choice, don't do it.

Questions ?