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# Emerging Nanoelectronics

# Preparing FP7

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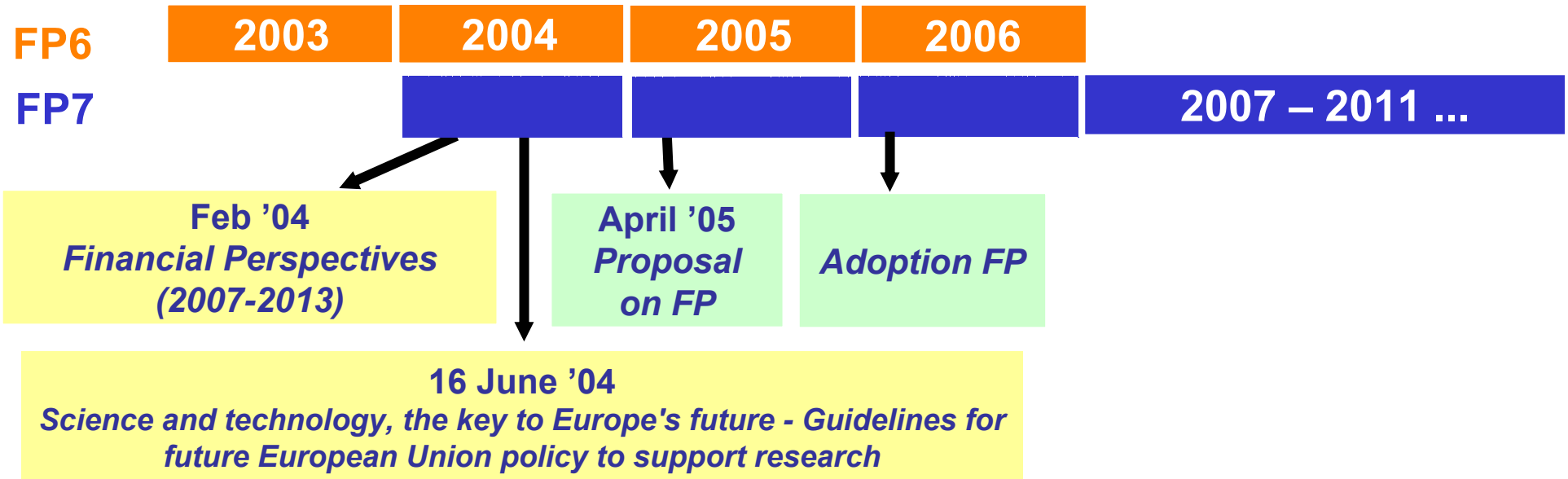
# Preparing FP7: The Roadmap and the 6+2 Axes




**FP7: 6+2 axes**

- ***Collaborative Research***
- ***European Technological Initiatives***
- ***ERC: Basic Research Grants for individual research teams***
- An attractive Europe for best Researchers
- ***Research Infrastructures***
- Co-ordination of national research programmes

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- Space (ESA)
- Security

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# Preparing FP7

- **IST in FP7**
  - ERC & Basic Technology Research in ICTs → Options Paper
  - Collaborative RTD:
    - *ISTAG (Working Group on Grand Challenges)*
    - *Strategic Orientations*
    - *FP7 Workshops:*
      - 21-22 Apr 04: FET FP7 Workshop
      - 12 Oct 04: ICT at the crossroads with Life Sciences
      - 8-9 Nov 04: Robotic Systems for extending Human Capabilities
      - 16 Dec 04: Emerging Nanoelectronics
  - European Technology Platforms
    - *Developments of ENIAC platform*
    - *Agenda 2020*

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# Emerging Nanoelectronics: Preparing for FP7

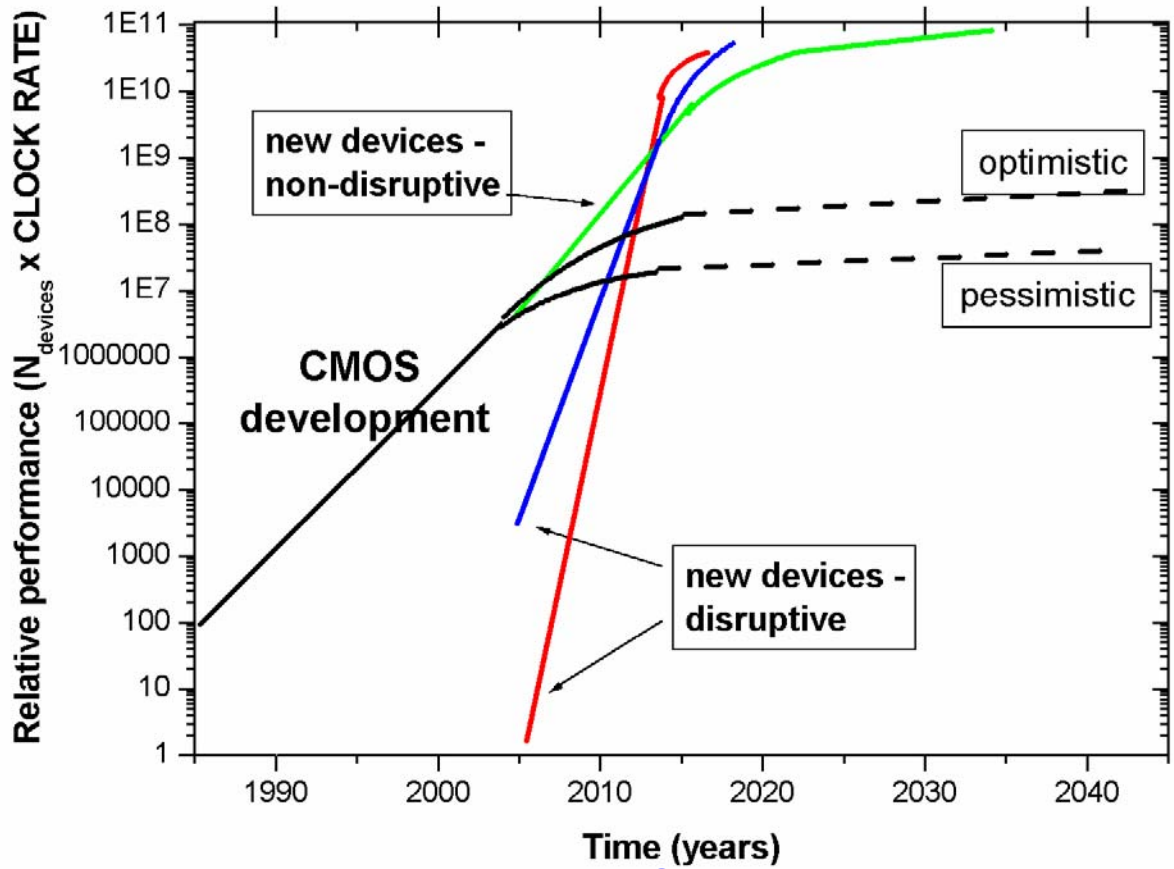
## Overall FP7 Workshop, Brussels, 21-22 April 2004

- Components
- Systems
- Intelligence

## Emerging Nanoelectronics Workshop, Brussels, 16 December 2004

- Draft Report now available: see http://www.cordis.lu/ist/fet/nid.htm
- PLEASE SEND US YOUR COMMENTS/INPUTS

# Why Emerging Nano R&D?
# 1. Limits of logic scaling




Source: Michael Forshaw, University College London

- CMOS: Limits of scaling & limits of benefits of scaling: frequency increase, power scaling, delays, etc.

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# ITRS ERD: Logic

- Non-conventional CMOS:

  pursuing the shrinking until the “16 nm node” in 2019?

- Charge-transport based emerging devices:

  Nanotubes, Nanowires, Tunnelling devices, etc.

- Breakthrough devices:

  Quantum, spin-based, molecular, etc.

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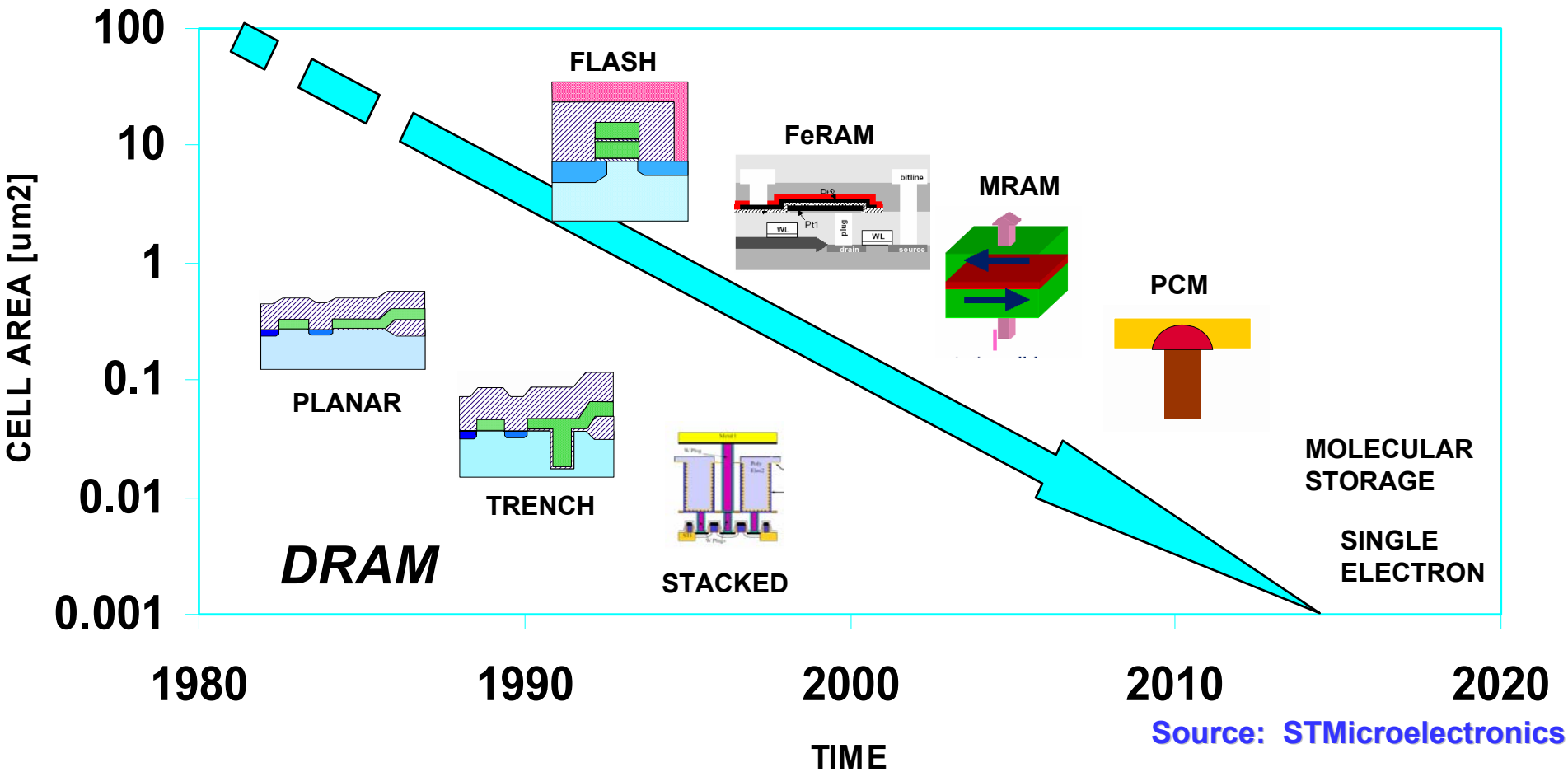
# ERD: Logic: Limiting Factors

Aim: Improve logic performance, density, cost, power

- Power dissipation density
- Tunnelling effects
- Discreteness of matter/dopants
- Limits of energy/device vs. thermal noise
- Beyond single devices: interconnections, etc.
- Patterning - manufacturing accuracy
- Yield
- Etc.

# Why Emerging Nano R&D?
# 2. Limits of memory scaling




- …and looking for solid-state non-volatile storage

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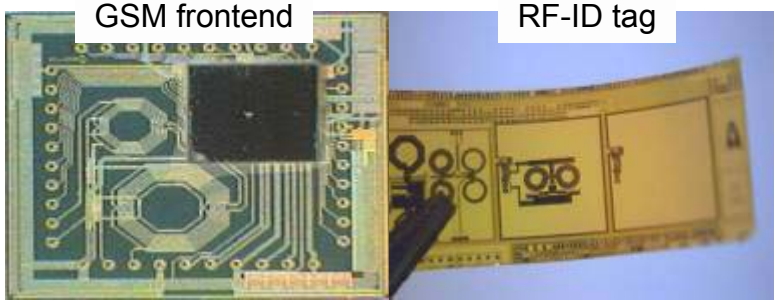
# ERD: Memories: Targets

Aim: Improve density, cost, retention time, write time & energy

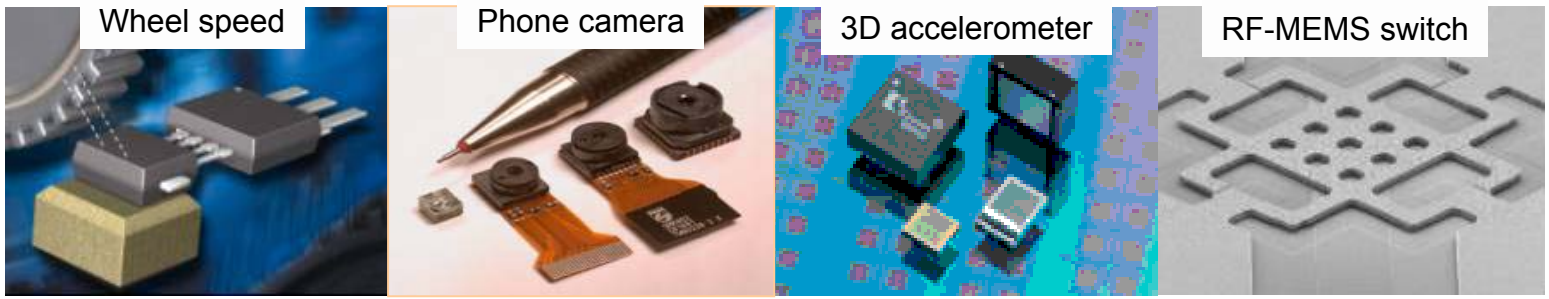
- Limits to scaling of charge-based devices?
- More open to alternative approaches?
- In development: FRAM, MRAM, PCRAM
- New approaches: MIM, molecular, single/few e-, etc.
- Manufacturing issues
- Yield, Fault tolerance

# Why Emerging Nano R&D?
# 3. Value-added functions

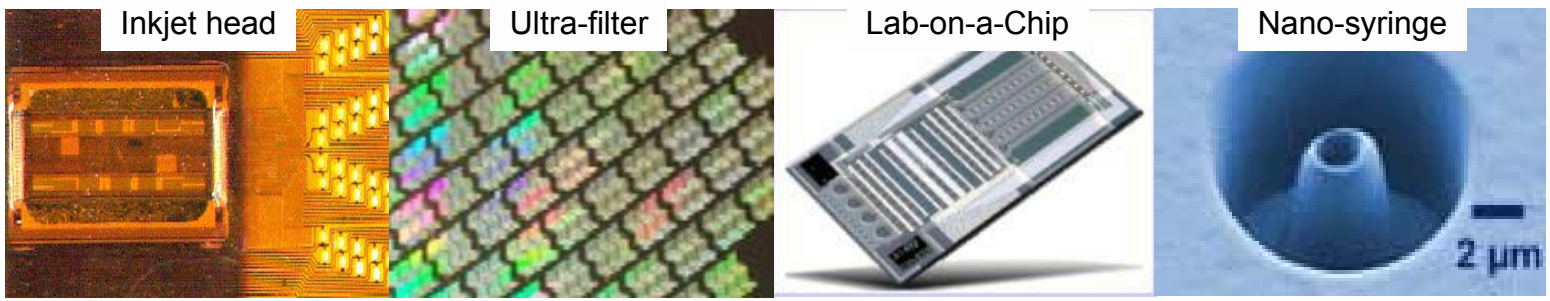
*integrated passives*




*sensors actuators*




*fluidics*




**Source: Philips**

- **Intelligent Systems that compute and interact**

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# Towards a Research Programme: Topics

- Multidisciplinary Vision-driven Research
  - Materials, Devices, Circuits, Architectures
  - Experimental fabrication & characterisation
  - Design - Modelling
  - Path towards mass-manufacturing~
- Curiosity-driven research
  - Science and technology
  - Not too many constraints

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# Towards a Research Programme: Organisation

- Collaborative Multidisciplinary Research
  - Development of concepts
  - Answering elementary limitations
  - Patenting
- Curiosity-driven research
  - New concepts – Proof of concept
- Access to Infrastructure
  - Needs to be managed & funded
  - Expect to become specialised
- Roadmap: New impetus?
- Link with ENIAC

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# Towards a Research Programme: Participants

- Majority expected from Academic and Research
- Role of industry
  - Research participant
  - Advise, assessment
- Mobility of researchers
  - Among partners in projects
  - “European single market” for researchers
- Synergy among various lines of action. Conference
- Integration of New Member States
  - Better awareness of potential
- International Cooperation

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# Additional Slides

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# ITRS ERD
# Memory Devices

- Phase change memory
- Floating body DRAM
- Nano floating gate memory
- Single/few electron memory
- Insulator resistance change memory
- Molecular memories

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# ITRS ERD
# Logic devices

- RSFQ
- Carbon Nanotubes
- Nanowire structures
- Crossbar structures
- Resonant tunnelling devices
- Single electron transistors
- Molecular devices
- Quantum cellular automata
- Spin transistors

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# ITRS ERD Architectures

- Quantum Cellular Automata Architecture
- Cellular nonlinear networks
- Fault-tolerant architectures
- Biologically-inspired architectures
- Coherent quantum computing

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# ITRS ERD Materials

- Material synthesis
  - Molecular synthesis
  - Thin film synthesis
  - Nanostructure synthesis
  - Self and directed assembly
  - Material interface, contacts
- Characterisation
  - Characterisation of chemical, structural, impurity, defect, electronic information with nanometer or even atomic scale
  - Characterisation of state properties
- Modelling and simulation