1. Titel van MJP: Nano-contamination control

Dit is een nieuw programma dat uitgewerkt moet worden.

2. Tot welk(e) van de 8 cluster(s) van technologieën behoort dit MJP:

Nanotechnologies; Engineering and fabrication technologies; Advanced Materials

3. Welke sleuteltechnologieën staan centraal:

Nano-contamination control is an in-situ key technology which mitigates contamination on the nanoscale in high-end production processes and tools such as those used in the semiconductor industry. To this end clever combinations of fluid dynamics, plasma physics and electrostatic engineering are enabling.

4. Positie NL:

The Netherlands, and more specifically Metropoolregio Brainport Eindhoven, is front-runner when it comes to (very) clean operation of high-end production processes. To a large extent, this urgency for cleanliness is driven by the semiconductor industry and the high-tech supply chain connected to it. In these industries, contamination with even the smallest particle, only tens of nanometers in size, will obstruct the elementary processes involved. Whereas until now the focus was on micrometer-sized contaminants, further shrinking the size of microchips urges the industry to stretch to preventing contamination on nanoscales as well. This stretch in research and development is especially driven by the unique Dutch ecosystem encompassing industrial parties, academia and knowledge institutes.

5. Korte beschrijving van voorgesteld meerjarenprogramma voor onderzoek en ontwikkeling:

The business success of an increasing amount of large Dutch industries, such as the semi-conductor industry (e.g. ASML, ASMI, NXP) and the high-precision production industry (e.g. VDL ETG, Prodrive Technologies), depends highly on whether sufficiently low levels of contamination with nanoparticles can be achieved. Clever combinations of fluid dynamics, plasma physics and electrostatic engineering open the way to control in-situ contamination by nanoparticles. Enabling factor of control is the permanent electric charge contaminating particles obtain in plasma. By carefully tailoring on the one hand this plasma-induced particle charge, and on the other hand the plasma boundary geometry, flow dynamics and the (externally applied) electric fields, nano-contaminants can be "lured" away from areas where they are harmful. In order to accomplish this way of contamination control, several technological and scientific issues need to be addressed urgently. For instance, the elementary processes behind plasma-charging of nano-contaminants and their interaction with ionizing radiation, gas flows and electrostatic fields are key. In addition, in-situ detection of particles much smaller than the wavelength of visible light is extremely difficult and therefore demands novel techniques to be developed. The goals of the proposed program are 1) developing the necessary fundamental knowledge regarding the issues raised above and 2) enabling the creation of novel in-situ contamination control and particle detection techniques.

6. Ecosysteem*:*

The ecosystem around this technology – which is mainly centralized within Brainport Eindhoven – is large and contains:

- Academic research groups in plasma physics, flow dynamics, electrostatics and high-precision engineering/robotics.
- Research institutes like DIFFER and participants of the "TO2-federatie" TNO and NLR
- A large amount of high-tech industrial parties such ASML, VDL ETG, Prodrive Technologies, NXP, ASM International, ASM ALSI, etc.

7. Organiserend vermogen*:*

"Nationale penvoerder" will be the Eindhoven University of Technology (TU/e).

8. Kans op maatschappelijke impact op korte en lange termijn:

The Netherlands, and in particular Metropoolregio Brainport Eindhoven, is the beating heart when it comes to the development of faster, smaller and greener microchips. Without doubt, these faster, smaller and greener microchips, co-enabled by this MJP, lay the foundation for significant developments to enable all of the four "*thematische Kennis & Innovatie Agenda's*".

9. Kans op economische impact op korte en lange termijn:
The economic impact is significant. With the *Semiconductor Yield Improvement Calculator* [1] one could estimate that an improvement of the yield of a new type of semiconductor fab by 1% (typical negative yield impact by nano-contamination) increases its profit by 5 M€/month, which translates to a profit impact of 60 M€ annually for a single fab. A comparable impact is expected in other/connected application areas.

Currently, this technology is on TRL-2 to TRL-3 level. Wide application of plasma-based nano-contamination control in the field is expected within 5-10 years. Currently, R&D departments of the above-mentioned industrial parties annually invest tens of millions of Euros internally already. This, together with the fact that nano-contamination will become more and more an issue due to down-scaling of semiconductor structures, ensures the willingness of private parties to invest both large and increasing amounts of money.

10. Krachtenbundeling:
Currently, 10 PhD students funded by both NWO and private parties are paving the way for this MJP. These projects will be fully entangled with the proposed MJP. Also, contamination control is one of the focal area of the High Tech Systems Center at the TU/e. Furthermore, several valuable and existing collaborations with foreign academic research groups in the field of plasma science, flow dynamics and electrostatic engineering will be strengthened along this MJP. Finally, other “sleuteltechnologie MJP’s” – especially in the fields of photonics and advanced materials seem mutually valuable for future collaboration.

11. Cross-over character:
From a scientific point of view, the proposed program contains fundamental and applied research in plasma physics, flow dynamics and electrostatics. The cross-over character is determined by the strong cross-over between beta sciences and engineering disciplines.

12. Indicatie van benodigde gemiddelde jaarlijkse financiering en commitments voor periode 2020-2023:
zie tabel

Bron	**Totaalbedrag (M€/jaar)**	**Waarvan reeds gecommitteerd**	**Waarvan te mobiliseren**
Private middelen	3	0,3	2,7
PPS toeslag	1,5	0,2	1,3
TO2 middelen			
NWO	5	0,2	4,8
Universiteiten/hogescholen	0,5	0,15	0,35
Regionale middelen (provincie, gemeente)	1		1
Departmentale middelen			
EU middelen	5		5
ROMs en InvestNL			
Anders, namelijk:			
Totaal bedrag (M€/jaar)	**16**	**0,85**	**15,15**

[1] https://www.quadrillion.com/roi.htm#Answer