Main results of the consultation to experts and stakeholders

We provide a brief summary of the **main conclusions**, where **experts** and **stakeholders** placed special emphasize and where coinciding opinions where found. The following points could by concluded (NOTE: the list is NOT ordered by priorities or degree of relevance):

1. **Nanotechnology** is generally acknowledged as a major driver for innovation, with the potential to enter any production area. Nevertheless, Microtechnologies will continue being crucial and should definitely not be disregarded, with existing markets expanding more and more for products integrating MEMS that will, in most cases, definitively not be substituted nor made obsolete by nanotechnologies.

2. For wide application of nanoparticles, processes for their industrial production in large quantities will need to be transferred from the laboratory and pilot scale to industrial production. Beyond the **fabrication of nanoparticles** itself, also effective dispersion for nanoscaled particles in matrix materials, as well as coating surfaces with nanoscaled materials, and **nanostructuring of surfaces and solids** (emphasizing also in 3D nanomanufacturing) for new and taylored properties, are important.

3. From the different technologies for **production of nanoparticles**, gas phases (e.g. graphene, fullerens and carbon nanotubes) and liquid phases (e.g. large quantities of magnetite, new methods based on high-boiling solvent, and biotechnology approaches – example: inorganic clusters by encapsulation of chemical substances in protein cells) were pointed out as relevant.

4. Technologies for **Micro- and Nano- multimaterial processing** , including specifically 3D structuring technologies, were identified as very important, since they enable flexible and cost-efficient manufacturing of multifunctional products made of different materials in practically all manufacturing sectors, like biotechnology (biosensors, microfluidics…), ICT (optoelectronics- optical+electronics), etc.

5. In this respect, the special relevance of **replication methods** (currently not yet widely used) was pointed out, since they may hold the potential to replace lithography for a number of applications. An important step would be in relation to the production of the master stamp, which is normally very expensive.

6. **Single material** technologies and products should nevertheless not be forgotten: a considerable number of technologies with promising industrial potential, both for existing and totally new products (like materials for transparent electronics), were brought to discussion by the experts and stakeholders.

7. **SPM technologies** collected contradictory opinions. Although critisized by its sequential (and therefore slow) character, alternative approaches for fast SPM technologies, including massive parallel scanning, may open the way to promising applications and to its possibly wide utilization in the industry, and are suggested as a relevant topic, with goal development from lab scale to industrial application.

8. Strong emphasize was placed also by many of the experts and stakeholders on **assembly, packaging and integration** for Micro-/Nano-technology based products. Despite latest advances, assembly and integration acounts for a major part of the total manufacturing costs in MST/NST.

9. **Improvement of existing processes and tools** for micro-/nano-assembly and integration (microgrippers, sensory based manipulation, image feedback, joining processes, heterogeneous assembly for electronics manufacturing -including innovation in solder paste for special and taylored properties, new printing and deposition technologies, etc.-, among others others) is important, but the experts and stakeholders also stressed the **need to develop promising, partially new, approaches** for cost efficient and reliable micro-/nanoassembly and 3D packaging, like mixed technologies with appropriate enabling joining techniques (e.g. direct integration of waveguides or fluidic structures onto electronics boards), quasi-monolythic approaches, or self-assembly.

10. **Knowledge based fabrication** with adequate intelligent data-bases for "design" of process chains for highly flexible and adaptable manufacturing was identified as a very relevant issue.

11. **Metrology, characterization and test** where identified as a key factor for the success of Micro- and Nanomanufacturing. Not only in former times the facility in metrology is too expensive, but also currently EU is still heavily relying on Japanese equipment, and also lack sufficient development of "in-process" metrology and integration with manufacturing processes. Measurement standards still do not exist for the simplest topographical properties, like roughness on the nm scale, whereas surface measurement in the nano- and subnano range was mentioned as relevant. Also in relation to metrology, issues like combination of metrology/inspection and manufacturing processes, and metrology for in-process monitoring, were specifically mentioned.

12. Several experts indicated the need for design solutions, such as **design methodology and tools** for evolution of the micro/nano manufacturing systems. Europe lacks nano-science and technology based product innovation, which could be addressed with new design, testing and prototyping tools (e.g. multi-scale analysis system, or numerical modelling of potential deposition processes). It must be noted that the required new design packages will have to be very different, as they have to include effects like quantum chemistry and quantum mechanics; therefore, a simple adaptation of the existing tools would most likely fail.

13. **Smart and miniaturized sensors and actuators,** as well as new methods to integrate them –including signal processing- for on-line control and supervision in the manufacturing process chain, machines, equipment, etc. was identified as a growing application area by several experts. It was also proposed the potential for self-diagnosis and recovery. Miniaturization in general was seen as a key factor, enabling less energy consumption, reduction of noise, lower costs, higher flexibility, etc.

14. **Environmental friendly production processes and equipment** were also mentioned as highly relevant by several experts and stake holders, as well as the potential for design for

dissasembly, higher recycling/reuse rates, use of ne active nano/micro materials to achieve dissasembly, as well as integration of nano/micro labels on products, in order to inentify different materials and recycle them properly.

15. Many experts indicated the high relevance of **integrative production technologies for Micro- and Nanomanufacturing Platforms**. Although some of the concepts discussed (intelligent control, modular interfaces, quality control, etc.) may not look very innovative or original, it was clear that there is a need to specifically address this issues in the frame of Micro- and Nanomanufacturing. Due to the specific properties of the micro- and nanoworld, these topics may in most cases not directly be adapted from the macro-manufacturing world (e.g. stiction problems when handling, quantum effects, limitation of optical inspection due to refraction and wavelengh, health issues related to fabrication of nanoparticles, lack of standards in micro- and nanodomain, etc.). Under integration was also frequently mentioned as relevant superclean room environments and less environmental demanding conditions.

16. Further to the issue of Micro- and Nanomanufacturing platforms, and its relation to the macro world and the sector oriented production industries, it was mentioned the convenience to consider separate **sectorial calls/priorities**, where inspiration for new applications could be achieved. It was also indicated the fact that well-known mass-production technologies, when looked at in detail, can be actually in some cases be related to micro- or nano-technologies, which may open the way to new applications and possibilities (e.g. textile industry and composite materials with glass and polymeric (micro)fibers- and the use of micro fiber glass technology for f-MEMS 3D technology)

17. Issues related to robotics, mechatronics, handling and feeding systems, etc. for Micro- and Nanomanufacturing platforms were often brought to discussion. One of the key needs was, according to many experts, towards **modularity and flexible, standardized interfaces**.

18. **Embedding of intelligence** in the production platforms and chains was indicated as a crucial means to enable the systemic integration into Micro- and Nanomanufacturing platforms with a high level of flexibility, scalability, reconfigurability and reliability.

19. **Reliability and quality** control are also key aspects to ensure the future of the European Micro- and Nanomanufacturing industry.

20. Up**scaling** and customization turned out to be also a relevant aspect, especially for enabling rapid **scaling** from large to small quantities and even be able to produced one-of-a-kind products. This should comprise also flexibility for integration of macro-, micro- and nanoprocesses and properties in a synergetic and systemic way.

21. **SMEs:** It was pointed out the difficulties for SMEs, which are normally specialized and cannot cover the whole range of micromanufacturing technologies and facilities. To deal with this problem, **distributed manufacturing (tools for the management, business processes and logistics)** associated to Micro- and Nanosystems where proposed as key need.