# Tables for the aim4np Report

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Table 1 Tracking errors of the metrology platform. The most critical error is the one in z-direction.

| | rms error | **peak-to-valley error** |
|---|---|---|
| X | 20 nm | **183 nm** |
| Y | 14 nm | **123 nm** |
| Z | 2 nm | **17 nm** |
| Rot-X | 0,11 µrad | **1,07 µrad** |
| Rot-Y | 0,11 µrad | **0,88 µrad** |
| Rot-Z | 0,32 µrad | **4,43 µrad** |

Table 2 Different sources and their relative contribution to the total uncertainty of height measurements

| *Source* | *Value* | *Distribution* | *Sensitivity* | *Standard uncertain* | *Rel. stand. uncertainty* |
|---|---|---|---|---|---|
| Alignment of the mirror to the piezo actuation axis | 100 ‘’ | Rectangular | $1-\cos(\alpha)$ |  | $6.9 \cdot 10^{-8}$ |
| Alignment of the piezo to the picodrift system | 60’’ | Rectangular | $1-\cos(\alpha)$ |  | $2.4 \cdot 10^{-8}$ |
| Resolution picodrift system | 1 pm | Rectangular | 1 | 0.6 pm |  |
| Vertical piezo calibration by picodrift system | 4.2 pm | Normal | $(19.7\ \text{nm})^{-1}$ |  | $2.1 \cdot 10^{-4}$ |
| Alignment of the standard to the AFM z axis | 1° | Rectangular | $1-\cos(\alpha)$ |  | $8.7 \cdot 10^{-5}$ |
| Z axis calibration coefficient | 12 pm | Normal | $(7.9\ \text{nm})^{-1}$ |  | $1.6 \cdot 10^{-3}$ |
| Squareness | 14° | Normal | $1-\cos(\alpha)$ |  | $3.0 \cdot 10^{-2}$ |
| Squareness uncertainty | 1.3° | Normal | $1-\cos(\alpha)$ |  | $2.6 \cdot 10^{-4}$ |

Table 3 Different sources and their relative contribution to the total uncertainty of lateral measurements.

| *Source* | *Value* | *Distribution* | *Sensitivity* | *Standard uncertain* | *Rel. stand. uncertainty* |
|---|---|---|---|---|---|
| Alignment mirror to piezo actuation axis | 1° | Rectangular | 1-cos(α) | | $8.7 \cdot 10^{-5}$ |
| Alignment standard to picodrift system | 60’’ | Rectangular | 1-cos(α) | | $2.4 \cdot 10^{-8}$ |
| Resolution picodrift system | 1 pm | Rectangular | 1 | 0.6 pm | |
| Lateral piezo calibration | 9.7 pm | Normal | $(21.7\ \mathrm{nm})^{-1}$ | | $4.5 \cdot 10^{-4}$ |
| Alignment standard to lateral AFM plane | 1° | Rectangular | 1-cos(α) | | $8.7 \cdot 10^{-5}$ |
| Correlation analysis software | 0.001 | Normal | 1 | | $1.0 \cdot 10^{-3}$ |
| Non-linearity<br>* Residue after correction | 10.5 nm<br>(1.4 nm)* | Normal | | 10.5 nm<br>(1.4 nm)* | |
| Squareness | 1.4° | Normal | 1-cos(α) | | $3.0 \cdot 10^{-4}$ |
| Squareness uncertainty | 0.16° | Normal | 1-cos(α) | | $3.9 \cdot 10^{-6}$ |

Table 4 Calibration results for the Z-axis for different nano scale step heights

| **Nominal step height /nm** | **Actual step height /nm** | **Measured step height /nm** | **Calibration coefficient /nm** |
|---|---|---|---|
| 10 | 9,89 | 12.38 | 0.799 |
| 5 | 4.95 | 6.12 | 0.809 |
| 2 | 1.98 | 2.52 | 0.785 |
| 1 | 0.99 | 1.19 | 0.833 |

Table 5 Overview of the impact for the different SME partners.

| *Industrial Partner* | *Originally expected impact* | *Currently expected Impact, Products, Exploitation* |
|---|---|---|
| Flubetech | (End-user of full instrument)<br>Fast, in-line measurements of the nano-roughness of coatings for ultra smooth plastic injection moulds, providing FT a reference position in this market<br>2M€/Y turnover within 3Y<br>5M€/Y turnover within 10Y | Original impact, however, in-line metrology may be delayed<br>In addition: Use of gained knowledge about the injection process thanks to new modelling software |
| Nanosurf | New product line within existing portfolio,<br>5% market share after ~ 5Y; ~ 12M€ increase in revenue | Z-axis only Metrology Platform for large gantry systems<br>Tip monitoring scheme for industrial applications [Licensing form project partners who own the patent]<br>High-end successor for NaniteAFM for industrial / OEM applications<br>Expected market share, volume and time of introduction t.b.d. |
| Nanoworld and Nanotools | Small, fast, self-sensing cantilevers and integrated sharp tips<br>targeted price 100€/piece<br>~60'000 probes/Y or ~ 6M€/Y | Novel self-sensing high speed AFM probes<br>Innovative through cantilever interconnection concept<br>New concept for mounting self-sensing probe<br>Novel integration of advanced tip technology<br>~ 6Y after end of project:<br>10k - 20k probes/Y<br>1.5 - 3M US$/Y |
| SIOS | Making step from laboratory to in-line metrology (very precise laser interferometry, positioning and in-line metrology)<br>Target price for provided sensor-set: 25k€ | extension of current product portfolio by [price t.b.d.]:<br>• vertical tracking sensor [Q4, 2017]<br>• lateral tracking sensor (no comparable sensor on market) [Q1, 2018]<br>• Dual-Laser light source with tuneable (2MHz- 15MHz) frequency difference [Q2, 2017] |

| *Industrial Partner* | *Originally expected impact* | *Currently expected Impact, Products, Exploitation* |
|---|---|---|
| VSL | Offer calibration services to customers | Providing traceability to customers of aim4np instruments<br>Provide measurement services with VSL equipment to customers<br>Virtual standard [ready by end of project]<br>Probe Calibration Methodology [needs further development] |

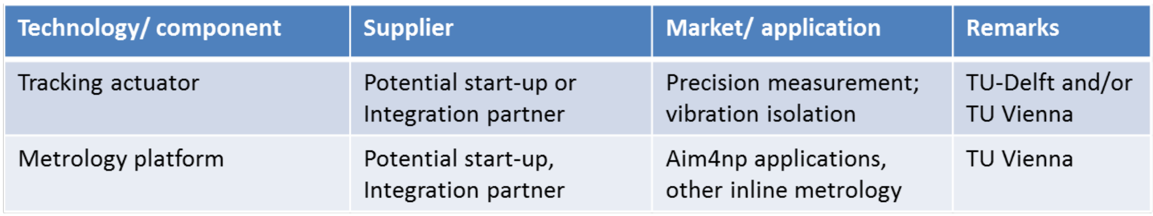
Table 6 Dissemination matrix

| What | to Whom | Goal | How to do it |
|---|---|---|---|
| Website | General Public | point of contact<br>General description of project | Contractor sets up the website, maintenance by admin. CO |
|  | Consortium | exchange of documents |  |
| Participation at Scientific Conferences | Scientific peers in the field of the project | Scientific discussion and peer review | Participation at conferences like:<br>EUSPEN<br>MNE |
| Participation at fairs, trade shows and exhibitions | general / broad industrial stakeholders | Gain awareness and interests of potential end-users | “Piggy-pack” on booths of partners |
| Publishing in scientific journals | scientific peers | Expose ideas and results to peers, generate awareness | normal publishing route |
| Exploitation Workshop | core targeted industrial group outside consortium | Gain interest of potential exploitation partners | Personal invitation of potential partners |
| Validation workshop | scientific and industrial stakeholders in the field of the project | Demonstrate the concept and its capability to end-users and potential exploitation partners | Personal and general invitation through Network of consortium and advisory board members |
| Site visits | specific member of industrial core group | F-2-F meeting with end-users and potential exploitation partners, tailored information, inquire about market, collaboration, synergies, | Address members from the network of (industrial) consortium partners and advisory board members. |

Table 7 Implementation of the dissemination matrix.

| **to Whom** | **What / Product** | **Goal, Topic** | **Reference, *Title*, Journal and/or Conference** |
|---|---|---|---|
| General Public | Website | Point of contact;<br>General description of project | www,aim4np.eu |
| General Public | Movie | General concept and basic solutions | *Automated in-line Metrology for Nanoscale Production*<br>https://www.youtube.com/watch?v=SUIfN1-gapo |
| Policymakers / broad industrial stakeholders | Participation in the exhibition and special events | Gain awareness, attract interests of potential end-users | *Automated in-line Metrology for Nanoscale Production* (shared booth with VSL)<br>Precision Fair 2014; Veldhoven The Netherlands<br>November 12/13, 2014<br>*Automated in-line Metrology for Nanoscale Production - aim4np* (dedicated booth plus scientific posters for each sub-topic)<br>Industrial Technology Conference 2016,<br>RAI, Amsterdam, The Netherlands ; June 22-24, 2016 |
| Core targeted industrial group (outside consortium) | Private Exploitation Workshop | Gain interest of potential exploitation partners | *Introduction into the new in-line metrology technique developed by aim4np - Chances and Challenges*<br>Liestal, Switzerland<br>October 23, 2014 |
| Scientific and industrial stakeholders in the field of the project | Validation workshop | Demonstrate the concept and its capability to end-users and potential exploitation partners | *Automated in-line Metrology for Nanoscale Production - aim4np*<br>Vienna University of Technology; Vienna, Austria<br>August 26, 2016 |
| Industry | EU Patent Application | protect IP | *Method for monitoring Radius and Shape Variations of Atomic Force Microscope Cantilever Tips and Device thereof*<br>EP15163207.2 |

Table 8 Platform exploitation

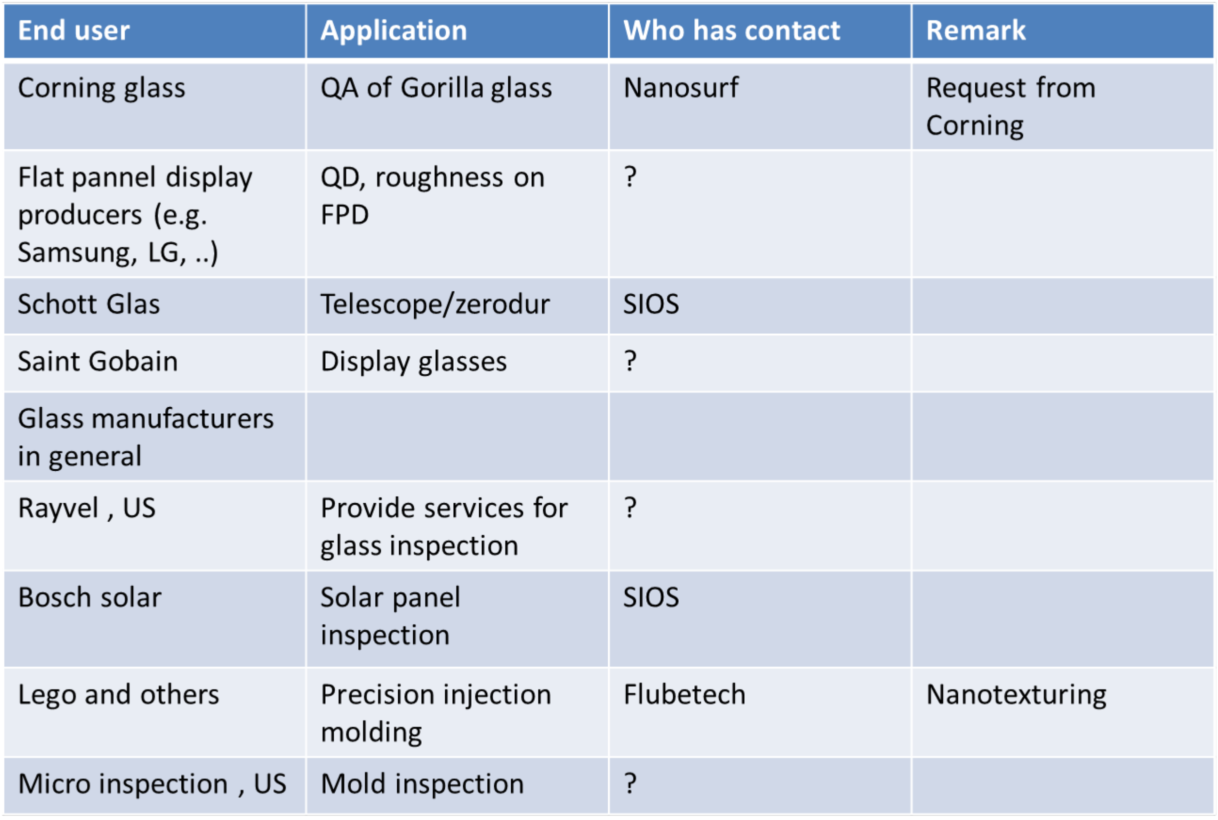


| Technology/ component | Supplier | Market/ application | Remarks |
|---|---|---|---|
| Tracking actuator | Potential start-up or Integration partner | Precision measurement; vibration isolation | TU-Delft and/or TU Vienna |
| Metrology platform | Potential start-up, Integration partner | Aim4np applications, other inline metrology | TU Vienna |

Table 9 Preliminary list of potential exploitation partners of the MP

| Integration partner | Application | Who has contact | Remark |
|---|---|---|---|
| Bosch, Siemens, ABB | Metrology solutions in production lines | | Would probably do a lot by themselves |
| FRT | Inspection systems | Nanosurf | Are already associated with consortium |
| Schneeberger | Produce FPD inspection stages | | |
| Newport | Precision stages | | |
| Aerotech | Precision stages | | |
| PI-Micos | Precision stages | | |
| Feinmess Dresden | Precision stages | | |
| MI Partners, NL | Mechatronic engineering | | |
| | | | |

Table 10 List of potential end users of the MP



| End user | Application | Who has contact | Remark |
|---|---|---|---|
| Corning glass | QA of Gorilla glass | Nanosurf | Request from Corning |
| Flat pannel display producers (e.g. Samsung, LG, ..) | QD, roughness on FPD | ? | |
| Schott Glas | Telescope/zerodur | SIOS | |
| Saint Gobain | Display glasses | ? | |
| Glass manufacturers in general | | | |
| Rayvel , US | Provide services for glass inspection | ? | |
| Bosch solar | Solar panel inspection | SIOS | |
| Lego and others | Precision injection molding | Flubetech | Nanotexturing |
| Micro inspection , US | Mold inspection | ? | |

Table 11 List of Innovations to be exploited by individual SMEs of the consortium

| Technology/ component | Supplier | Market/ application | Remarks |
|---|---|---|---|
| Lateral sensor | SIOS | Machinery | |
| Vertical sensor | SIOS | Machinery | |
| Heterodyne laser source | SIOS | Machinery | Possible OEM |
| Virtual standards | VSL | AFM, SEM, microscopy | Measurement services |
| Probe calibration method | VSL | | Measurement services |
| AFM head | Nanosurf | Metrology | |
| 1-D or SW compens. for AFM | Nanosurf | Metrology | |
| Nanoinjection SW | IQS/ potential start-up | Molding industry | |
| Tip monitoring | TUD/CSIC, licensing | AFM companies | IP in progress |
| Self-sensing piezo probes | Nanoworld/ Nanotools | AFM companies, various applications, end users | |