

Dübendorf, 8. November 2001

Ihre Referenz:

Fon direkt:

Unsere Referenz:

Fax direkt:

Reliability-Check Nanotechnology: Questionnaire 2001

Ladies and Gentlemen

EMPA, the Swiss Federal Laboratories for Materials Testing and Research, participates in TOP NANO 21 with a service cluster project "Reliability of Nanostructured Materials and Devices" (KTI 5202.1, page 178-179 of Second Annual Report 2001, 16.10.01). Within this project a "Nanoworld Reliability Network" was established (<http://www.empa.ch/englisch/zentren/zzt/>), to share knowledge, tools and techniques, and expertise on reliability issues in the world of nanostructured materials and devices. Enclosed please find a brief summary of the project including a description of the services provided to TOP NANO 21 partners.

Also enclosed is a questionnaire on reliability. We kindly ask you to fill in your answers and to send it back to the given address **until November 30**. The individual replies will be treated confidentially and the anonymously evaluated results will be sent back to each participant.

The purpose of the questionnaire is to investigate how Swiss industry (especially those companies participating in TOP NANO 21) tackles the foreseeable reliability problems with products which are strongly based on nanotechnology. Reliability theory and physics of failure of macro-/ microworld are known to be only partially applicable to nanoworld. Therefore, many reliability issues must be treated differently for nanosystems as for micro- or macrosystems.

If this information doesn't concern you, please forward it to the responsible person. Thank you very much for your help.

Looking forward to your reply, we remain.

Yours sincerely,

Dr. Urs Sennhauser
Reliability Centre

Enclosure

Part A General quality and reliability assurance activities in your company

1. How many employees work in your company?

Number	1-30	31-60	61-150	151-300	>301
x					

2. Do you have a product quality assurance system or program?

Yes	No

If yes, please specify:

Yes

3. Do you have a product reliability assurance system or program?

Yes	No

If yes, please specify:

Yes

4. How many employees work for quality / reliability assurance?

Number

5. How many of them perform technical quality/reliability assurance (see 6.)?

Number

6. Which of the following activities are covered by your quality/ reliability assurance?

- a) in general
- b) specifically for your TOP NANO 21 project

Activity	a)	b)	in house	external
reliability estimation within feasibility study				
purchased items				
reliability definition in specs, contracts etc.				
incoming inspection: identification				
incoming inspection: parameter measurement				
qualification tests				
other:				
own product				
failure rate prediction				
reliability, availability and maintainability analysis				
FMEA (failure mode and effects analysis)				
FTA (fault tree analysis)				
other:				
own product / process				
in-process tests, statistical process control				
final and acceptance test				
functional tests				
qualification tests				
burn-in, run-in				
(accelerated) stress tests				
failure analysis				
research on physics of failures				
field data analysis				
corrective action tools e.g. 8D				
other:				

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7. What is the intensity of reliability activities during the life cycle phases of your nano-product / application (please rate 0-5, 5 is highest intensity)?

In addition, please, estimate the percentage of the reliability activity (in terms of cost) within the phase.

Phase	Intensity	%
preliminary study, feasibility study		
definition		
design		
development		
prototype / demonstrator		
processing /production		
test		
operation (repair, field returns, maintenance)		
disposal		

Part B Nanotechnology reliability objectives (for your specific TOP NANO 21 project or new NT-product(s))

1. What TOPNANO21 category is your product ?

Category	x
tips and probes	
replication / surfaces	
optical devices / light sources	
machining / manipulation and assembly	
novel materials	
biomaterials	
sensors	
instrumentation / devices	
energy storage / environmental applications / photovoltaics	
data storage	
other (or further explanation)	

2. Is this product with respect of its main functionality....

Product type	x
....a completion	
an enhancement	
....a replacement	
....a new type of product (new business field)	
....other:	

3. Describe the main function of your product/application and the specific nanotechnology it is based on.

Please describe:

4. Your final nano-product/application consists of or contains the following materials:

Material (specify)	x
semiconductor	
metal	
ceramics	
composites	
organics	
glass	
film / bulk material	
other categories:	

5. Describe the environment in which your product / application will operate:
(e.g. temperature 0-40°C , humidity 30-60% , mechanical vibration,....)

Parameter	Range

6. What is the expected lifetime of your nano-product?
During this lifetime, what is its duty ratio (ratio of operating time to lifetime)?

Life time	x	duty [%]
single mission		
mission time: storage time before mission:		
<2 years		
2-5 years		
5-10 years		
10-20 years		
> 20 years		

7. The main reason for reliability considerations for your nanotechnology product is....

Reason	x
...safety	
...reliability unknown	
...customer satisfaction	
...ecological reasons	
...economical reasons	
...other:	

8. In which phase is your current nanotechnology project?

Phase of current project	x
evaluation of new technology/product	
feasibility study	
research	
development	
prototype / demonstrator	
introduction into fabrication	
processing and fabrication	
other:	

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**9. What are the major concerns in your nano project?
(please rate 0-5, 5 is highest concern)?**

Concerns / goals	Rating
achieve functionality	
performance	
establish production process	
mass fabrication	
yield	
reliability	
cost	

Part C Physics of failure and failure analysis

1. What are your activities in failure analysis?

Activities	in-house	external
no activity		
failure registration / statistics		
literature studies		
physical / chemical failure analysis		
experimental validation		
scientific modeling of failure mechanism		
research project		
other:		

**2. In case of failed nano-product: Can the failure mode be specified?
(e.g. electrical short/open, parameter drift, rupture, separation...)**

No	
Yes:	

**3. In case of failed nano-product: Can the failure mechanism be specified?
(e.g. fatigue, corrosion, diffusion, electromigration...)**

No	
Yes:	

**4. In case of failed nano-product: are the (accelerating) drivers known?
(e.g. temperature, humidity, vibration, contamination, current density, UV-radiation....)**

No	
Yes:	

**5. Which instruments/tools are used for failure analysis?
(e.g. SEM, FIB, TEM, STM, AFM, SAM, ESCA...)**

Instrument / tool	in house	external

Part D Necessities and requirements

1. With respect of the actual state of the art of today's technology do you think that reliability is still important?

Reliability is	x
extremely important (even today)	
important	
not important	
has to be considered	
other statement:	

2. For the emerging field of nanotechnology, especially for your product applications, do you think that reliability considerations have to be made?

Nano-Reliability is	x
critical and has to be studied	
important but is not a major problem	
is already built into nanotechnology	
has not be considered	
other statement:	

3. In which reliability field are your major needs and would you like to have more support?

Major needs in reliability engineering	x
none	
consulting	
failure analysis	
tests (screening, stress, environmental, accelerated....)	
statistical evaluation of failures	
physics of failure modeling (life time models)	
other:	

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Part E Varia and comments

Please give any additional comments or remarks you have concerning this questionnaire!

1. For me, this questionnaire was...

This reliability-check was	x
unnecessary	
interesting	
a new stimulus	
worthless	
waste of time	
worth considering	
other statements:	

2. Unfortunately you forgot to ask the following question(s):

3. Other comments or remarks

4. Enclosures

Please, send the questionnaire to the following address **until November 30, 2001**.

EMPA
 Dr. U. Sennhauser
 Reliability Centre
 Überlandstrasse 129
 CH-8600 Dübendorf