Glass for Energy & Information Technology. Road Maps

Thank you for providing your assessment of the key technical issues pertaining to the application of glass in energy and information technologies. Altogether 101 elements of varying importance to glass applications are identified in 12 roadmap diagrams.
At the end, after you have evaluated and provided your assessment of the various R&D issues, you will have three ‘overall’ questions for assessing the relative importance of: (a) the 101 roadmap elements, (b) 10 technologies, and (c) 14 properties/processing topics, in relation to the broader perspective of energy and information. Please choose and rank 3 to 8 most important choices for each of these questions.

In short, we are requesting you to:
1. Provide information about yourself (optional), so that we may contact you for further information/clarification, if needed. The overall assessment and opinion of individuals will remain anonymous.
2. Identify specific roadmaps (I through XII) that relate to your expertise and interests. Next, go through different Parts of a given roadmap, one Part at a time.
3. Consider all the topics in a given Part in relation to their importance to the area of the given roadmap as well as overarching application of glass. Rank each topic in order of decreasing importance i.e. ‘1’ being the most crucial topic, etc.
4. In the ‘Comments’ box, please add any topic(s) that you see missing from the list. Also feel free to give your opinion regarding the timeline assigned to various topics.
5. Finally, we would rather have your assessment based on partial information or educated guess than no input at all.

Please note: You can go back and resume / edit your survey at anytime until you have completed and submitted your responses. To save your responses please click [Next] button or [Done] button at end of page or survey.
Thank-you.

Glass for Energy & Information Technology. Road Maps

1. Please enter name, affiliation, e-mail (optional)

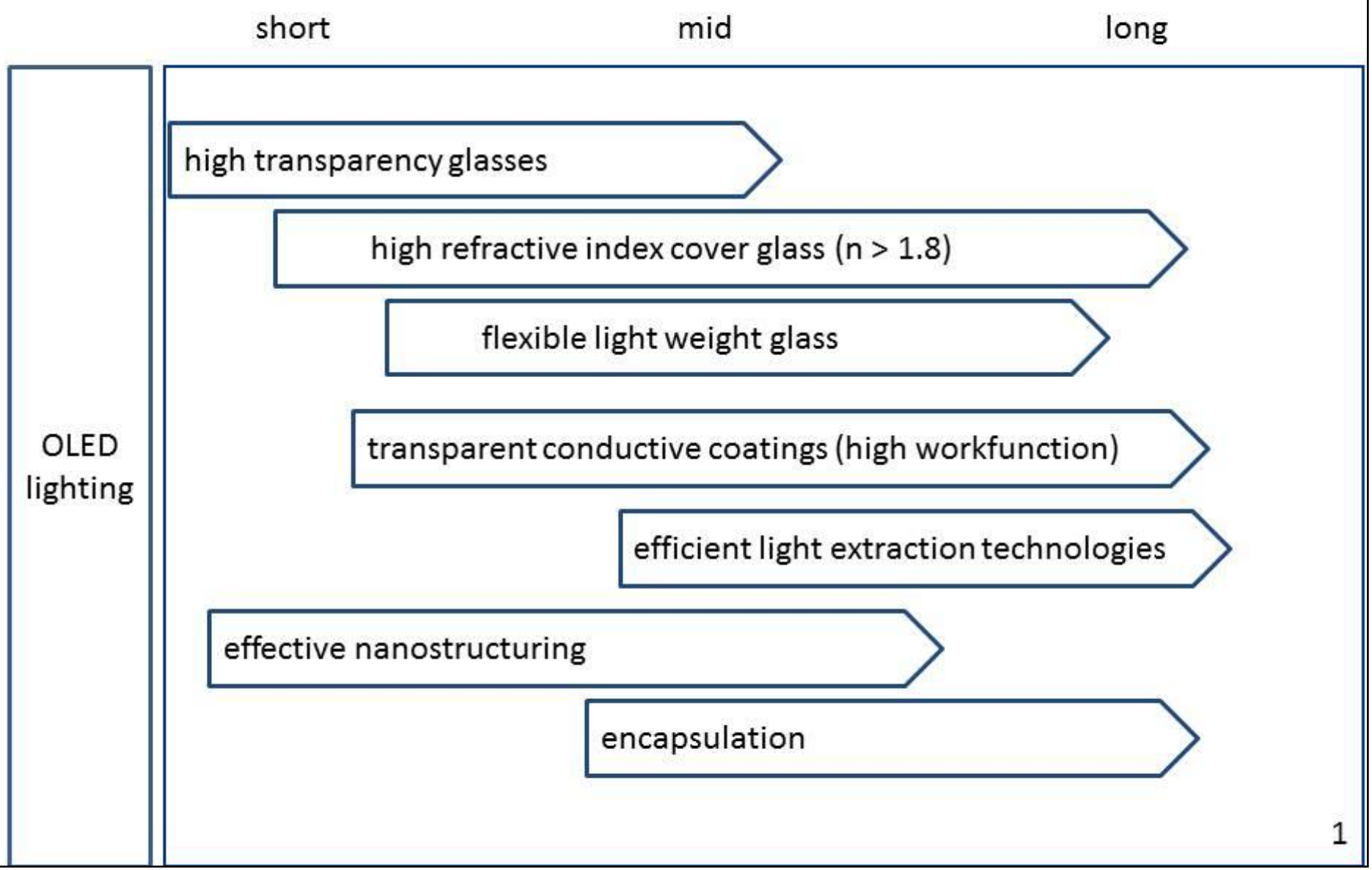
Name:

Affiliation:

Country:

Email Address:

Roadmap I: Applications in Energy Technology

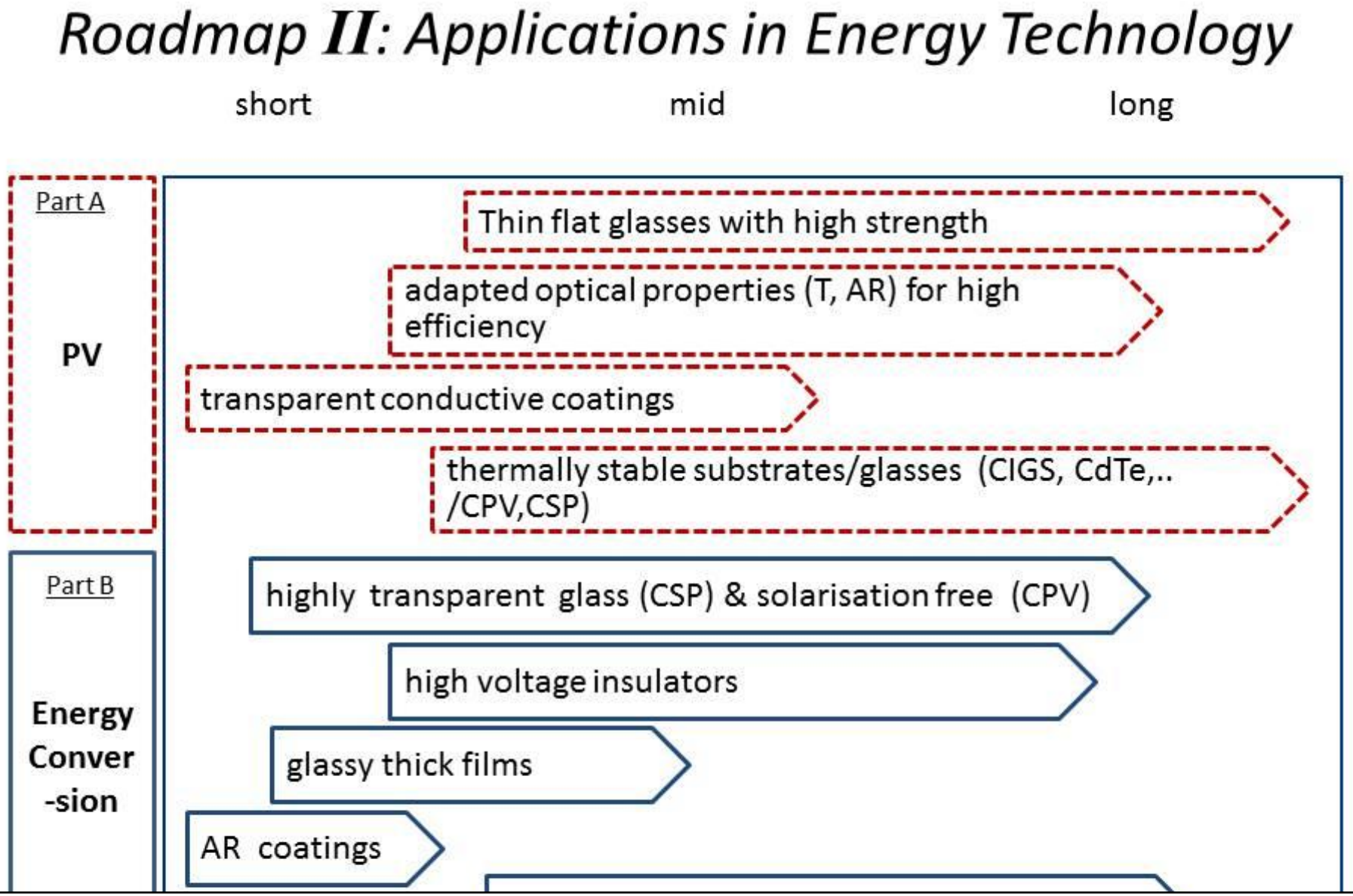


Glass for Energy & Information Technology. Road Maps

2. Roadmap I.
Applications in Energy Technology. OLED Lighting
Please rank topics in order of priority of importance to you.
Check "No opinion" if topic not relevant to you or of no interest.

	1	2	3	4	5	6	7	No opinion
1) high transparency glasses	○	○	○	○	○	○	○	○
2) high refractive index cover glass (n>1.8)	○	○	○	○	○	○	○	○
3) flexible light weight glass	○	○	○	○	○	○	○	○
4) transparent conductive coatings (high workfunction)	○	○	○	○	○	○	○	○
5) efficient light extraction technologies	○	○	○	○	○	○	○	○
6) effective nanostructuring	○	○	○	○	○	○	○	○
7) encapsulation	○	○	○	○	○	○	○	○

Comment


Roadmap II: Applications in Energy Technology
short
mid
long
Part A
PV
Thin flat glasses with high strength
adapted optical properties (T, AR) for high efficiency
transparent conductive coatings
thermally stable substrates/glasses (CIGS, CdTe,.. /CPV,CSP)
Part B
Energy Conver -sion
highly transparent glass (CSP) & solarisation free (CPV)
high voltage insulators
glassy thick films
AR coatings

3. Roadmap II. Applications in Energy Technology
Part A. PV.
Please rank topics in order of priority of importance to you.
Check "No opinion" if topic not relevant to you or of no interest.

	1	2	3	4	No opinion
8) thin flat glasses with high strength	○	○	○	○	○
9) adapted optical properties (T,AR) for high efficiency	○	○	○	○	○
10) transparent conductive coatings	○	○	○	○	○
11) thermally stable substrates/glasses (CIGS, CdTe, ../CPV, CSP)	○	○	○	○	○

Comments

Glass for Energy & Information Technology. Road Maps

4. Roadmap II. Applications in Energy Technology.

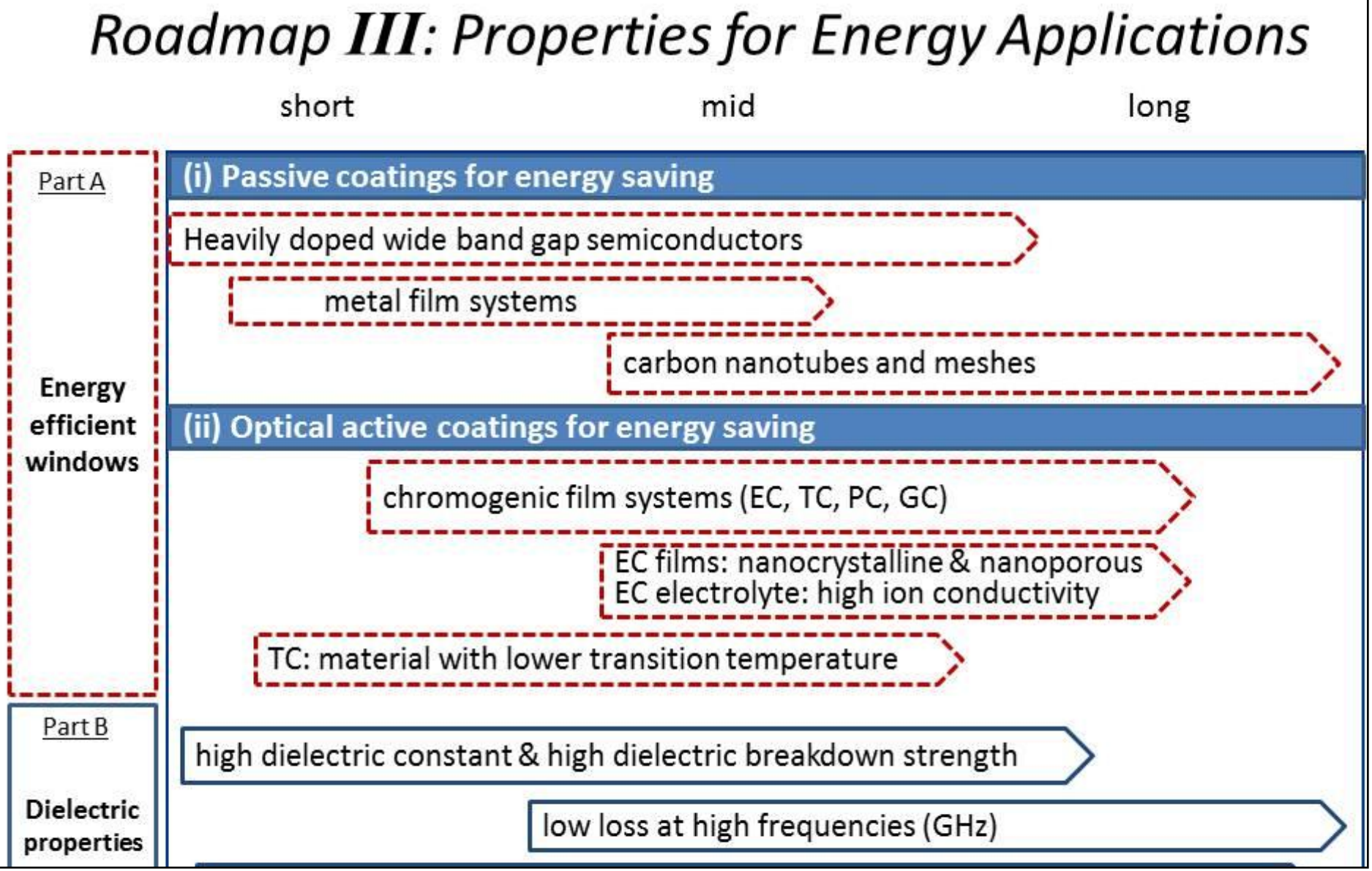
Part B. Energy Conversion

Please rank topics in order of priority of importance to you.

Check "No Opinion" if topic not relevant to you or of no interest.

	1	2	3	4	5	No opinion
12) highly transparent glass (CSP) and solarisation free (CPV)	○	○	○	○	○	○
13) high voltage insulators	○	○	○	○	○	○
14) glassy thick films	○	○	○	○	○	○
15) AR coatings	○	○	○	○	○	○
16) Anti-fouling coatings	○	○	○	○	○	○

Comments


Roadmap III: Properties for Energy Applications
short
mid
long
Part A
Energy efficient windows
(i) Passive coatings for energy saving
Heavily doped wide band gap semiconductors
metal film systems
carbon nanotubes and meshes
(ii) Optical active coatings for energy saving
chromogenic film systems (EC, TC, PC, GC)
EC films: nanocrystalline & nanoporous
EC electrolyte: high ion conductivity
TC: material with lower transition temperature
Part B
Dielectric properties
high dielectric constant & high dielectric breakdown strength
low loss at high frequencies (GHz)

Ultrathin; low impurity level (alkali); pore-free; low number of defects 3

5. Roadmap III. Properties for Energy Applications
Part A. Energy efficient windows (i) Passive coatings for energy saving
Please rank topics in order of importance to you.
Check "No opinion" if topic not relevant to you or of no interest

	1	2	3	No opinion
17) heavily doped wide band gap semiconductors	○	○	○	○
18) metal film systems	○	○	○	○
19) carbon nanotubes and meshes	○	○	○	○

Comments

6. Roadmap III. Properties for Energy Applications
Part A. Energy efficient windows (ii) Optical active coatings for energy saving
Please rank topics in order of priority of importance to you.
Check "No opinion" if topic not relevant to you or of no interest.

	1	2	No opinion
20) chromogenic film systems (EC, TC, PC, GC)	○	○	○
21) EC films: nanocrystalline & nanoporous / EC elecrolyte: high ion conductivity	○	○	○

Comments

Glass for Energy & Information Technology. Road Maps

7. Roadmap III. Properties for Energy Applications

Part B. Dielectric Properties

Please rank topics in order of priority of importance to you.

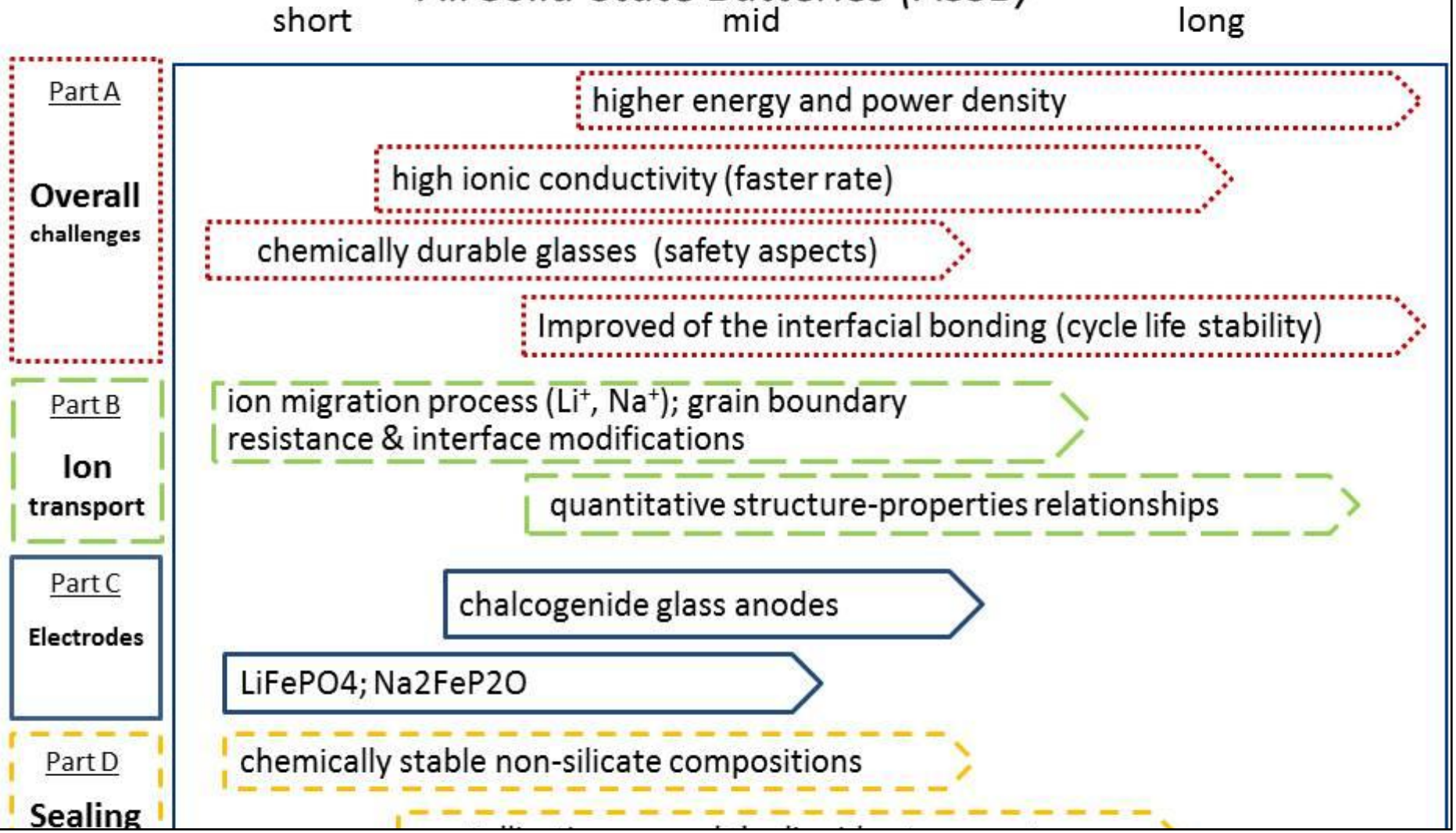
Check "No opinion" if topic not relevant to you or of no interest

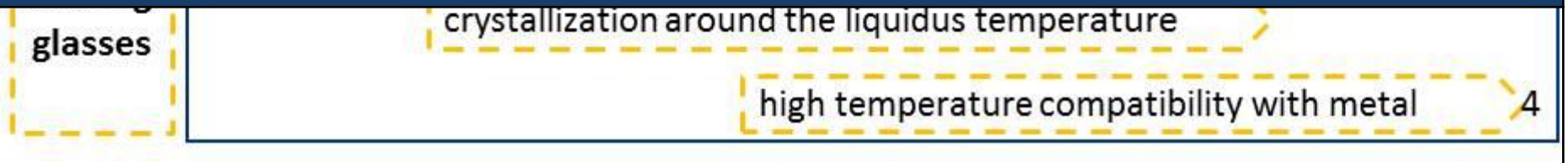
	1	2	3	No opinion
22) high dielectric constant & high dielectric breakdown strength	○	○	○	○
23) low loss at high frequencies (GHz)	○	○	○	○
24) Ultrathin; low impurity level (alkali); pore-free; low number of defects	○	○	○	○

Comments

Roadmap IV: Energy Storage Technology

All Solid State Batteries (ASSB)





8. Roadmap IV. Energy Storage Technology. All Solid State Batteies (ASSB)
Part A. Overall Changes
Please rank topics in order of priority of importance to you.
Check "No opinion" if topic not relevant to you or of no interest

	1	2	3	4	No opinion
25) higher energy and power density	○	○	○	○	○
26) high ionic conductivity (faster rate)	○	○	○	○	○
27) chemically durable glasses (safety aspects)	○	○	○	○	○
28) improved of the interfacial bonding (cycle life stability)	○	○	○	○	○

Comments

9. Roadmap IV. Energy Storage Technology. All Solid State Batteies (ASSB)
Part B. Ion transport
Please rank topics in order of priority of importance to you.
Check"No opinion" if topic not relevant to you or of no interest.

	1	2	No opinion
29) ion migration process (Li+, Na+); grain boundary resistance & interface modifications	○	○	○
30) quantitative structure-properties relationships	○	○	○

Comments

Glass for Energy & Information Technology. Road Maps

10. Roadmap IV. Energy Storage Technology. (ASSB)
Part C. Electrodes
Please rank topics in order of priority of importance to you.
Check "No opinion" if topic not relevant to you or of no interest

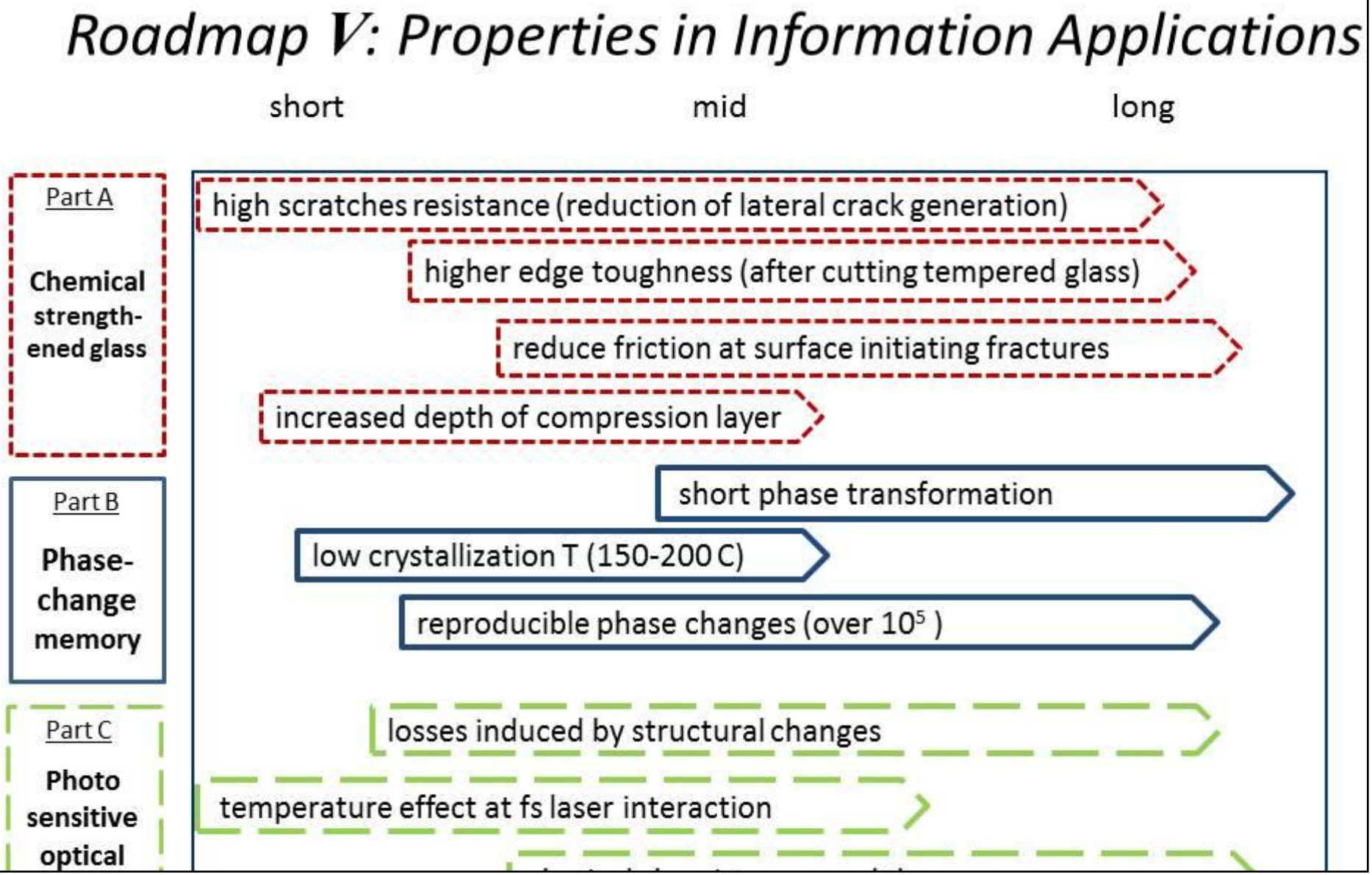
	1	2	No opinion
31) chalcogenide glass anodes	○	○	○
32) LiFePO4; Na2FeP2O	○	○	○

Comments

11. Roadmap IV. Energy Storgae Technology. (ASSB)
Part D. Sealing glasses
Please rank topics in order of priority of importance to you.
Check "No opinion" if topic not relevant to you or of no interest

	1	2	3	No opinion
33) chemically stable non-silicate compositions	○	○	○	○
34) crystallization around the liquidus temperature	○	○	○	○
35) high temperature compatibility with metal	○	○	○	○

Comments


Roadmap V: Properties in Information Applications
short
mid
long
Part A
Chemical strength-ened glass
high scratches resistance (reduction of lateral crack generation)
higher edge toughness (after cutting tempered glass)
reduce friction at surface initiating fractures
increased depth of compression layer
Part B
Phase-change memory
short phase transformation
low crystallization T (150-200 C)
reproducible phase changes (over 10^5)
Part C
Photo sensitive optical
losses induced by structural changes
temperature effect at fs laser interaction

material

physical chemistry around the oxygen 5

12. Roadmap V. Properties in Information Applications
Part A. Chemical strengthened glass.
Please rank topics in order of priority of importance to you.
Check "No opinion" if topic is not relevant to you or of no interest.

	1	2	3	4	No opinion
36) high scratches resistance (reduction of lateral crack generation)	○	○	○	○	○
37) higher edge toughness (after cutting tempered glass)	○	○	○	○	○
38) reduce friction at surface initiating fractures	○	○	○	○	○
39) increased depth of compression layer	○	○	○	○	○

Comments

Glass for Energy & Information Technology. Road Maps

13. Roadmap V. Properties in Information Applications
Part B. Phase-change memory.
Please rank topics in order of priority of importance to you.
Check "No opinion" if topic not relevant to you or of no interest.

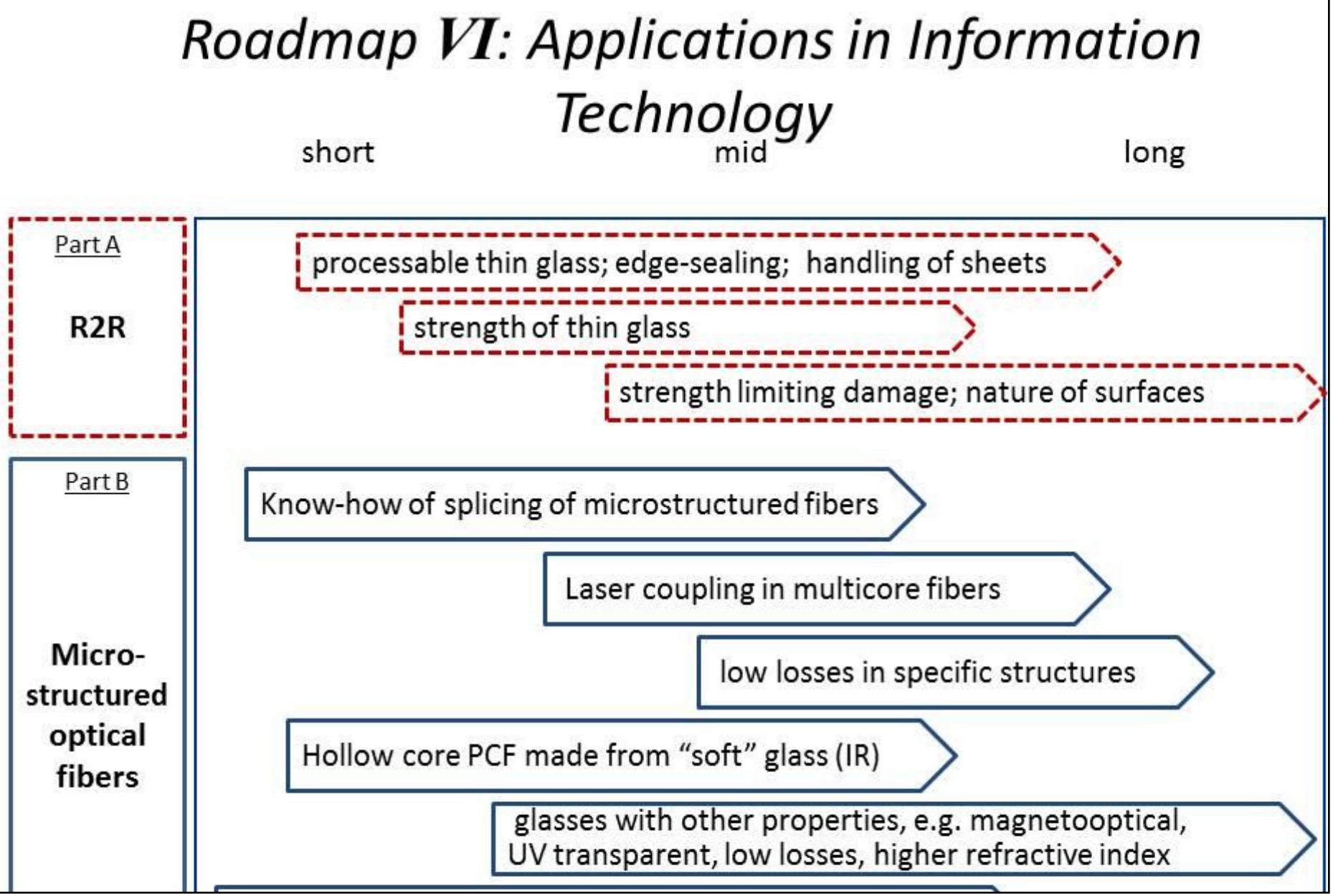
	1	2	3	No opinion
40) short phase transformation	○	○	○	○
41) low crystallization T (150-200 C)	○	○	○	○
42) reproducible phase changes (over 10 to power of 5)	○	○	○	○

Comment

14. Roadmap V. Properties in Information Applications
Part C. Photo senstive optical material.
Please rank topics in order of priority of importance to you.
Check "No opinion" if topic not relevant to you or of no interest.

	1	2	3	No opinion
43) losses induced by structural changes	○	○	○	○
44) temperature effect at fs laser interaction	○	○	○	○
45) physical chemistry around the oxygen	○	○	○	○

Comments


Roadmap VI: Applications in Information Technology
short
mid
long
Part A
R2R
processable thin glass; edge-sealing; handling of sheets
strength of thin glass
strength limiting damage; nature of surfaces
Part B
Micro-structured optical fibers
Know-how of splicing of microstructured fibers
Laser coupling in multicore fibers
low losses in specific structures
Hollow core PCF made from "soft" glass (IR)
glasses with other properties, e.g. magnetooptical, UV transparent, low losses, higher refractive index

alternative techniques for nanoscale glass fiber structure

15. Roadmap VI. Applications in Information Technology
Part A. R2R
Please rank topics in order of priority of importance to you.
Check "No opinion" if topic not relevant to you or of no interest.

	1	2	3	No opinion
46) processable thin glass; edge-sealing; handling of sheets	○	○	○	○
47) strength of thin glass	○	○	○	○
48) strength limiting damage; nature of surfaces	○	○	○	○

Comments

Glass for Energy & Information Technology. Road Maps

16. Roadmap VI. Applications in Information Technology

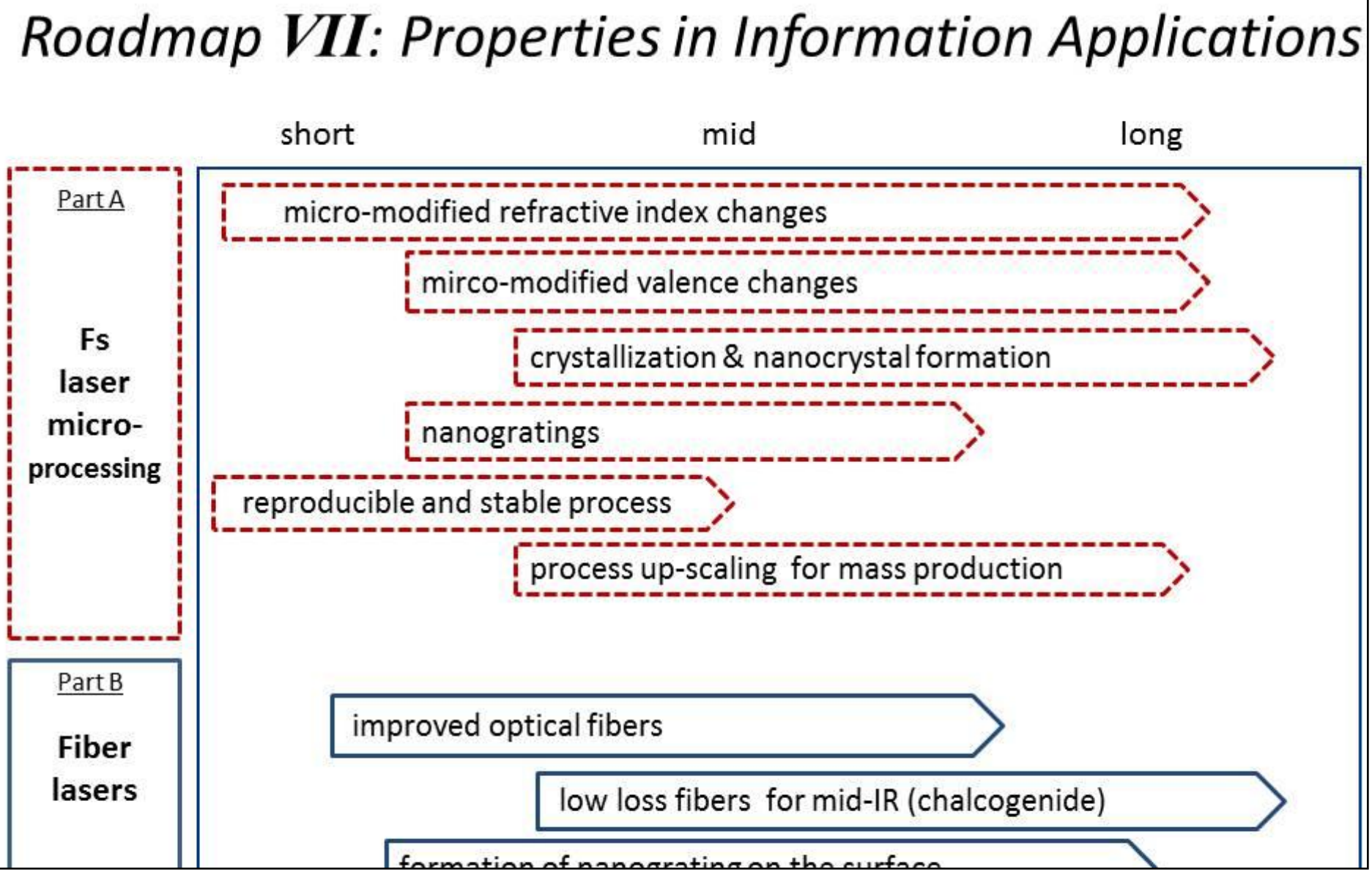
Part B. Micro-structured optical fibers.

Please rank topics in order of priority of importance to you.

Check "No opinion" if topic not relevant to you or of no interest.

	1	2	3	4	5	6	No opinion
49) Know-how of splicing of microstructured fibers	○	○	○	○	○	○	○
50) Laser coupling in multicore fibers	○	○	○	○	○	○	○
51) low losses in specific structures	○	○	○	○	○	○	○
52) Hollow core PCF made from “soft” glass (IR)	○	○	○	○	○	○	○
53) glasses with other properties, e.g. magnetooptical, UV transparent, low losses, higher refractive index	○	○	○	○	○	○	○
54) alternative techniques for nanoscale glass fiber structure	○	○	○	○	○	○	○

Comments


Roadmap VII: Properties in Information Applications
short
mid
long
Part A
Fs laser micro-processing
micro-modified refractive index changes
mirco-modified valence changes
crystallization & nanocrystal formation
nanogratings
reproducible and stable process
process up-scaling for mass production
Part B
Fiber lasers
improved optical fibers
low loss fibers for mid-IR (chalcogenide)

formation of nanograting on the surface

7

17. Roadmap VII. Properties in Information Applications

Part A. Fs laser micro-processing.

Please rank topics in order of priority of importance to you.

Check "No opinion" if topic not relevant to you or of no interest.

	1	2	3	4	5	6	No opinion
55) micro-modified refractive index changes	○	○	○	○	○	○	○
56) mirco-modified valence changes	○	○	○	○	○	○	○
57) crystallization & nanocrystal formation	○	○	○	○	○	○	○
58) nanogratings	○	○	○	○	○	○	○
59) reproducible and stable process	○	○	○	○	○	○	○
60) process up-scaling for mass production	○	○	○	○	○	○	○

Comments

Glass for Energy & Information Technology. Road Maps

18. Roadmap VII. Properties in Information Applications

Part B. Fiber lasers.

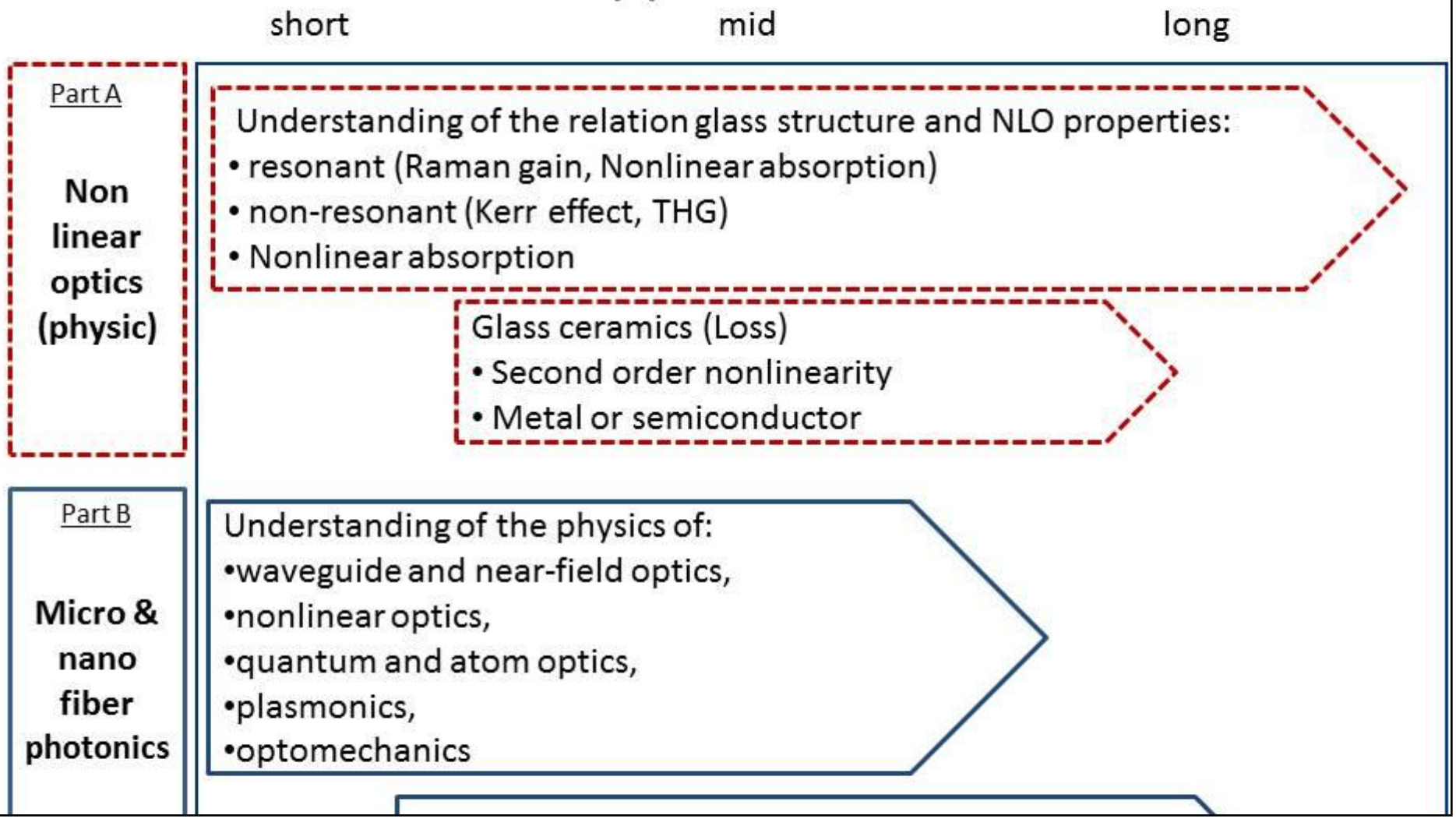
Please rank topics in order of priority of importance to you.

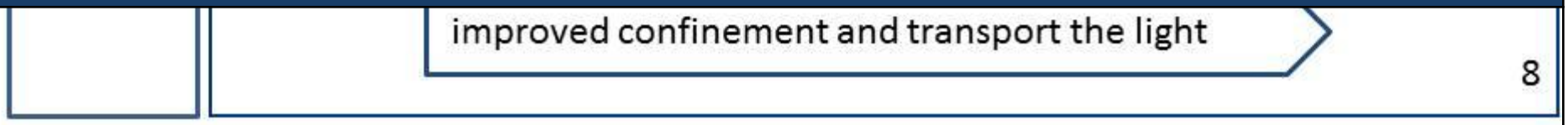
Check "No opinion" if topic not relevant to you or of no interest.

	1	2	3	No opinion
61) improved optical fibers	○	○	○	○
62) low loss fibers for mid-IR (chalcogenide)	○	○	○	○
63) formation of nanograting on the surface	○	○	○	○

Comments

Roadmap VIII: Properties in Information Applications





19. Roadmap VIII. Properties in Information Applications.
Part A. Non-linear optics (physic)
Please rank topics in order of priority of importance to you.
Check "No opinion" if topic not relevant to you or of no interest.

	1	2	No opinion
64) Understanding of the relation glass structure and NLO properties: resonant (Raman gain, Nonlinear absorption); non-resonant (Kerr effect, THG); Nonlinear absorption	○	○	○
65) Glass ceramics (Loss): Second order nonlinearity; Metal or semiconductor	○	○	○

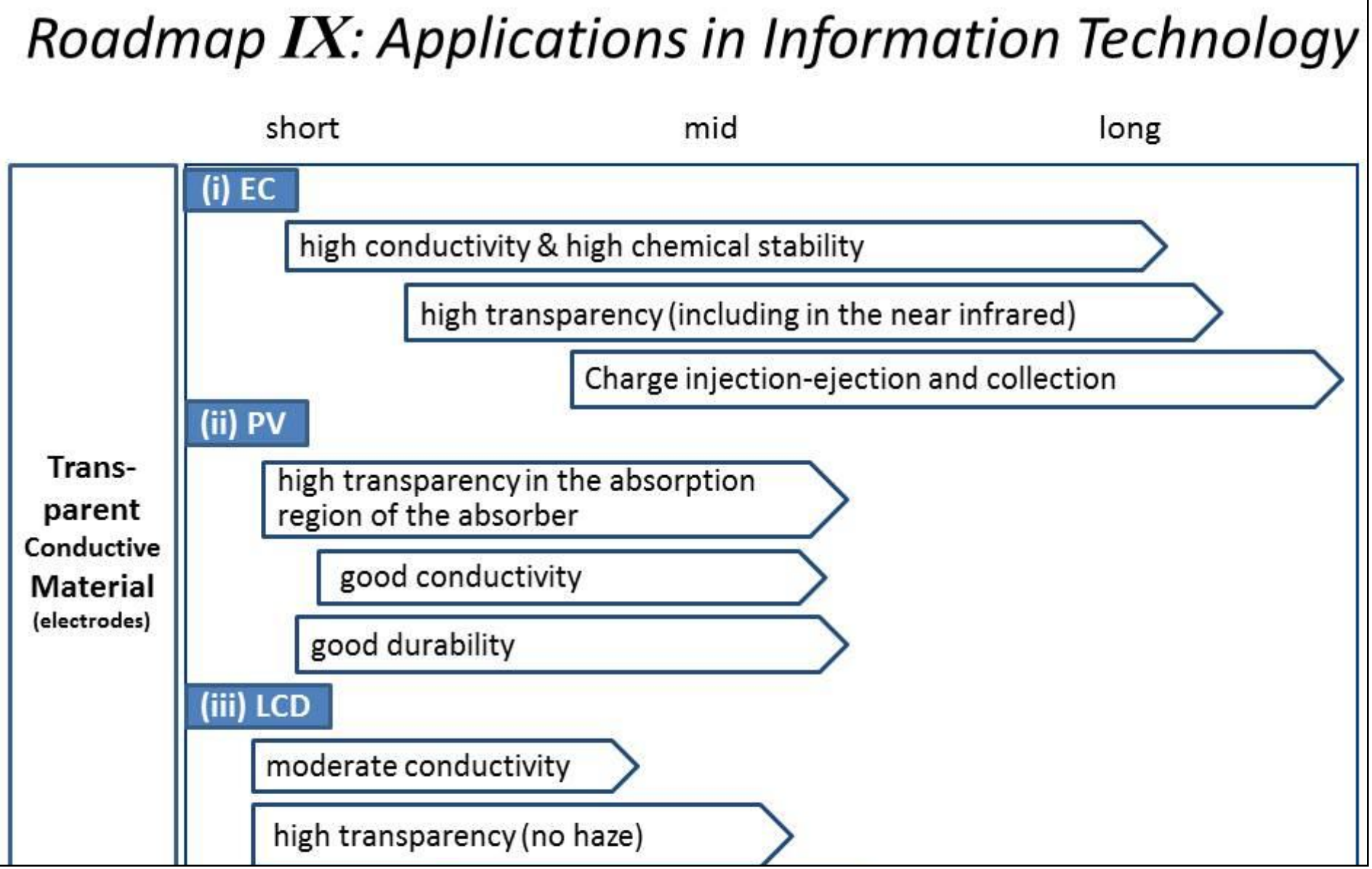
Comments

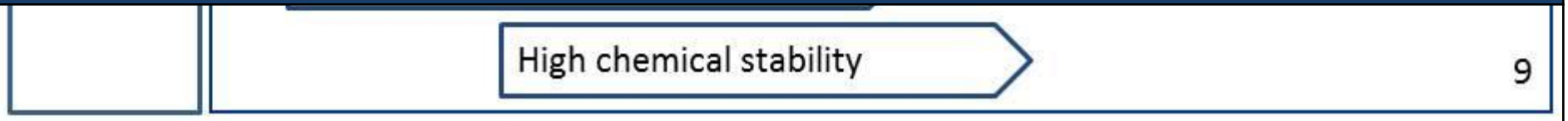
20. Roadmap VIII. Properties in Information Applications.
Part B. Micro & nano fiber photonics.
Please rank topics in order of priority of importance to you.
Check "No opinion" if topic not relevant to you or of no interest.

	1	2	No opinion
66) Understanding of the physics of: waveguide and near-field optics; nonlinear optics; quantum and atom optics; plasmonics; optomechanics	○	○	○
67) improved confinement and transport the light	○	○	○

Comments

Glass for Energy & Information Technology. Road Maps


Roadmap IX: Applications in Information Technology
short
mid
long
Trans-parent Conductive Material (electrodes)
(i) EC
high conductivity & high chemical stability
high transparency (including in the near infrared)
Charge injection-ejection and collection
(ii) PV
high transparency in the absorption region of the absorber
good conductivity
good durability
(iii) LCD
moderate conductivity
high transparency (no haze)



21. Roadmap IX. Applications in Information Technology
Transparent Conductive Material (Electrodes)
(i) EC
Please rank topics in order of priority of importance to you.
Check "No opinion" if topic not relevant to you or of no interest.

	1	2	3	No opinion
68) high conductivity & high chemical stability	○	○	○	○
69) high transparency (including in the near infrared)	○	○	○	○
70) Charge injection-ejection and collection	○	○	○	○

Comments

Glass for Energy & Information Technology. Road Maps

22. Roadmap IX. Applications in Information Technology.
Transparent Conductive Material (Electrodes)
(ii) PV
Please rank topics in order of priority of importance to you.
Check "No opinion" if topic not relevant to you or of no interest.

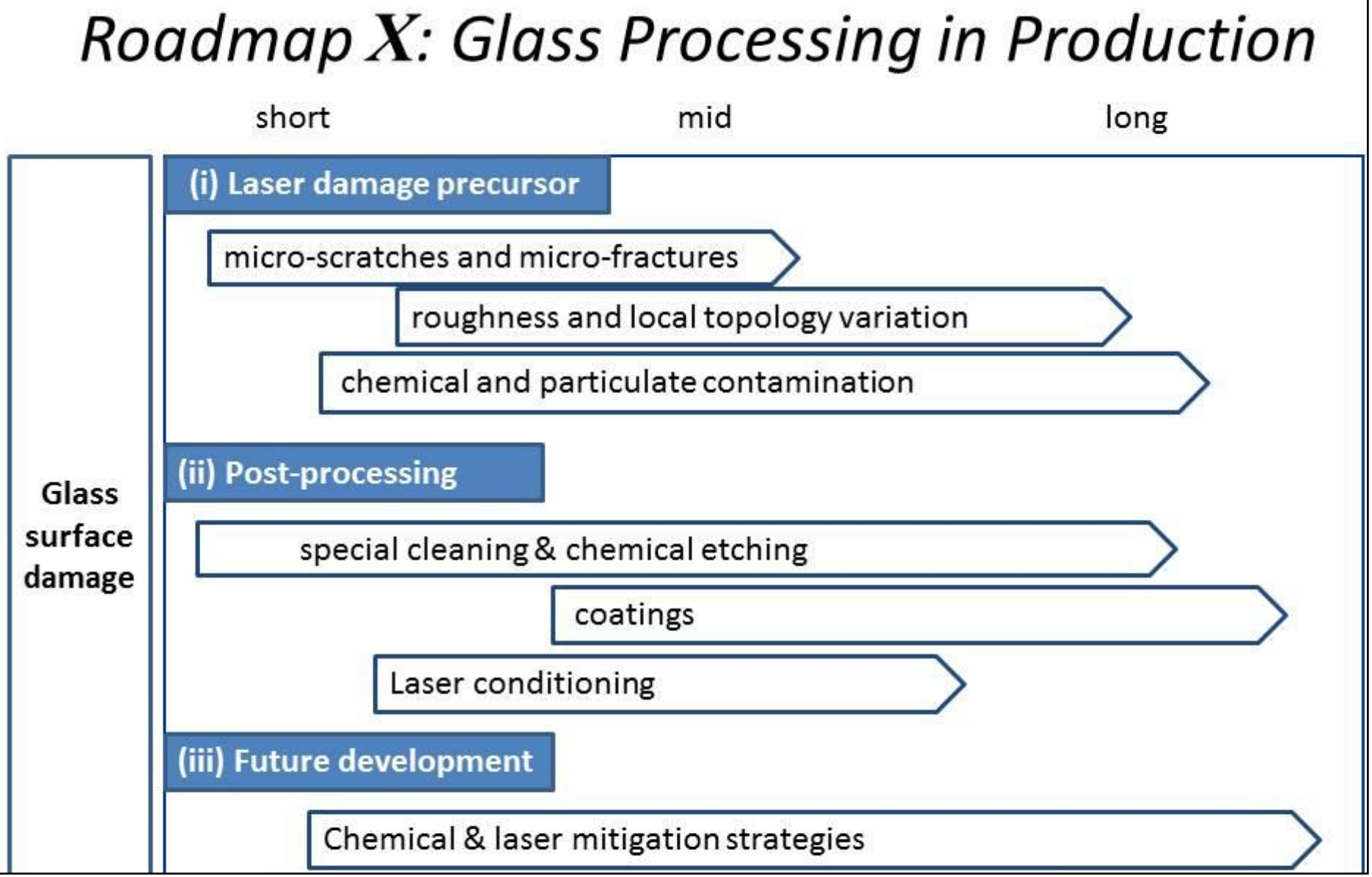
	1	2	3	No opinion
71) high transparency in the absorption region of the absorber	○	○	○	○
72) good conductivity	○	○	○	○
73) good durability	○	○	○	○

Comments

23. Roadmap IX. Applications in Information Technology.
Transparent Conductive Material (Electrodes)
(iii) LCD
Please rank topics in order of priority of importance to you.
Check "No opinion" if topic not relevant to you or of no interest.

	1	2	3	No opinion
74) moderate conductivity	○	○	○	○
75) high transparency (no haze)	○	○	○	○
76) High chemical stability	○	○	○	○

Comments


Roadmap X: Glass Processing in Production
short
mid
long
Glass surface damage
(i) Laser damage precursor
micro-scratches and micro-fractures
roughness and local topology variation
chemical and particulate contamination
(ii) Post-processing
special cleaning & chemical etching
coatings
Laser conditioning
(iii) Future development
Chemical & laser mitigation strategies

24. Roadmap X. Glass Processing in Production
Glass Surface Damage.
(i) Laser damage precursor
Please rank topics in order of priority of importance to you.
Check "No opinion" if topic not relevant to you or of no interest.

	1	2	3	No opinion
77) micro-scratches and micro-fractures	○	○	○	○
78) roughness and local topology variation	○	○	○	○
79) chemical and particulate contamination	○	○	○	○

Comments

Glass for Energy & Information Technology. Road Maps

25. Roadmap X. Glass Processing in Production
Glass Surface Damage.
(ii) Post-processing
Please rank topics in order of priority of importance to you.
Check "No opinion" if topic not relevant to you or of no interest.

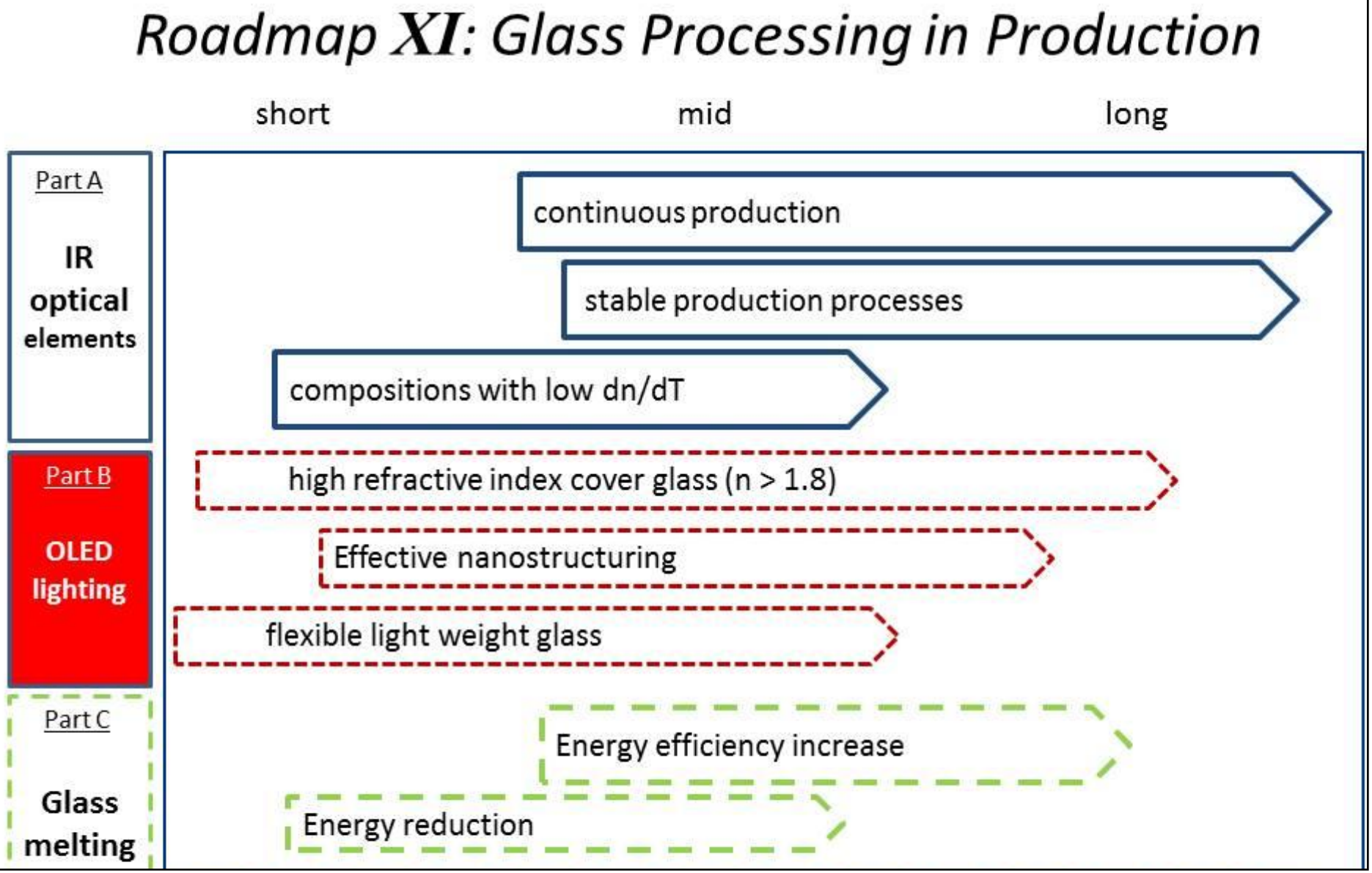
	1	2	3	No opinion
80) special cleaning & chemical etching	○	○	○	○
81) coatings	○	○	○	○
82) Laser conditioning	○	○	○	○

Comments

26. Roadmap X. Glass Processing in Production
Glass Surface Damage.
(iii) Future development
Please rank topics in order of priority of importance to you.
Check "No opinion" if topic not relevant to you or of no interest.

	1	2	No opinion
83) Chemical & laser mitigation strategies	○	○	○
84) High fluence multi-layer dielectrics; AR coatings	○	○	○

Comments


Roadmap XI: Glass Processing in Production
short
mid
long
Part A
IR optical elements
continuous production
stable production processes
compositions with low dn/dT
Part B
OLED lighting
high refractive index cover glass (n > 1.8)
Effective nanostructuring
flexible light weight glass
Part C
Glass melting
Energy efficiency increase
Energy reduction

27. Roadmap XI. Glass Processing in Production
Part A. IR optical elements
Please rank topics in order of priority of importance to you.
Check "No opinion" if topic not relevant to you or of no interest.

	1	2	3	No opinion
85) continuous production	○	○	○	○
86) stable production processes	○	○	○	○
87) compositions with low dn/dT	○	○	○	○

Comments

28. Roadmap XI. Glass Processing in Production
Part B. OLED lighting
Please rank topics in order of priority of importance to you.
Check "No opinion" if topic not relevant to you or of no interest.

	1	2	3	No opinion
88) high refractive index cover glass (n > 1.8)	○	○	○	○
89) effective nanostructuring	○	○	○	○
90) flexible light weight glass	○	○	○	○

Comments

Glass for Energy & Information Technology. Road Maps

29. Roadmap XI. Glass Processing in Production

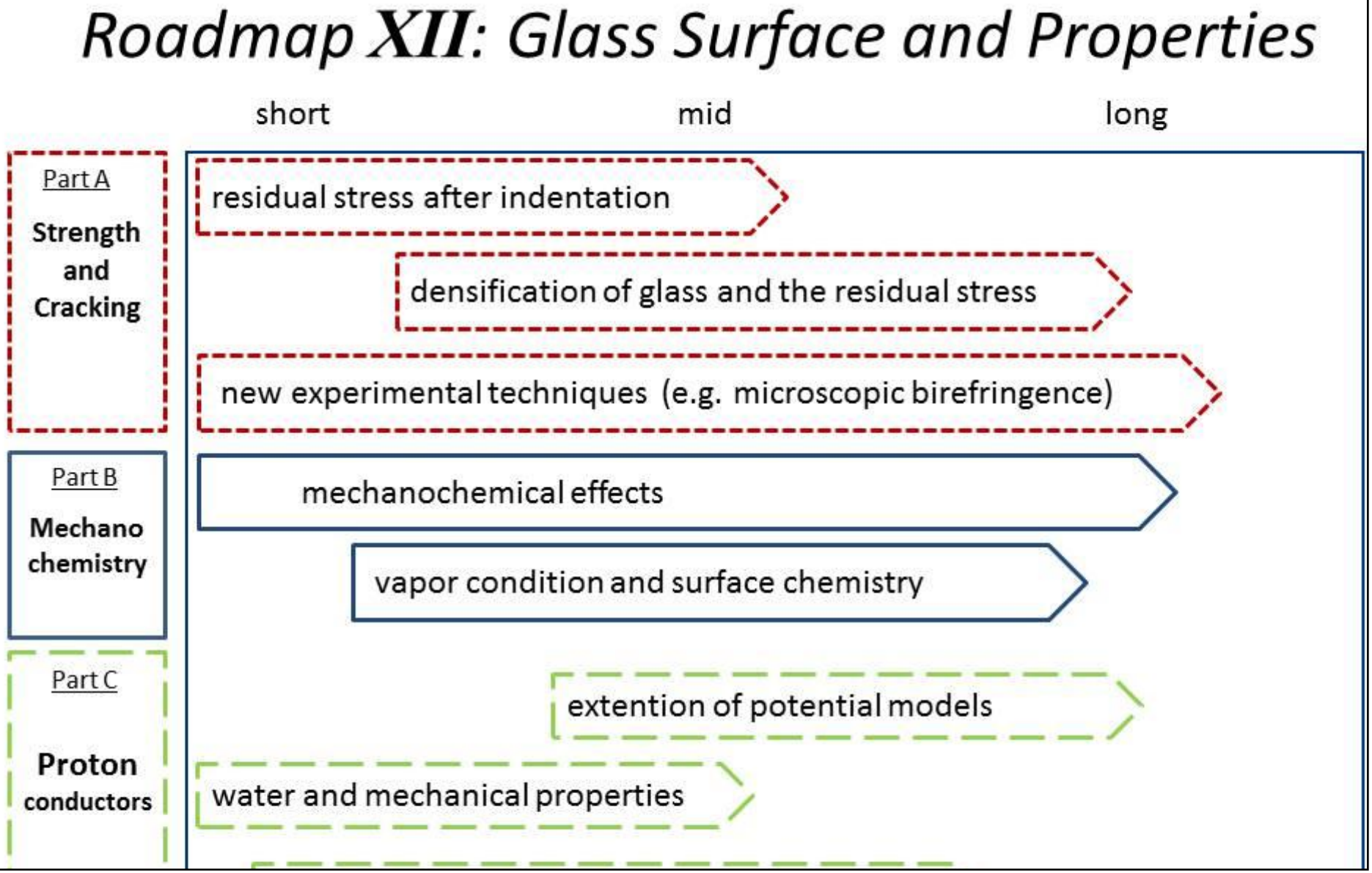
Part C. Glass melting

Please rank topics in order of priority of importance to you.

Check "No opinion" if topic not relevant to you or of no interest.

	1	2	3	No opinion
91) energy efficiency increase	○	○	○	○
92) energy reduction	○	○	○	○
93) environmental boundary conditions	○	○	○	○

Comments


Roadmap XII: Glass Surface and Properties
short
mid
long
Part A
Strength and Cracking
residual stress after indentation
densification of glass and the residual stress
new experimental techniques (e.g. microscopic birefringence)
Part B
Mechano chemistry
mechanochemical effects
vapor condition and surface chemistry
Part C
Proton conductors
extention of potential models
water and mechanical properties

effect of water on radiation damage

12

30. Roadmap XII. Glass Surface and Properties.
Part A. Strength & Cracking
Please rank topics in order of priority of importance to you.
Check "No opinion" if topic not relevant to you or of no interest.

	1	2	3	No opinion
94) residual stress after indentation	○	○	○	○
95) densification of glass and the residual stress	○	○	○	○
96) new experimental techniques (e.g. microscopic birefringence)	○	○	○	○

Comments

31. Roadmap XII. Glass Surface and Properties.
Part B. Mechanochemistry
Please rank topics in order of priority of importance to you.
Check "No opinion" if topic not relevant to you or of no interest.

	1	2	No opinion
97) mechanochemical effects	○	○	○
98) vapor condition and surface chemistry	○	○	○

Comments

Glass for Energy & Information Technology. Road Maps

32. Roadmap XII. Glass Surface and Properties.

Part C. Proton Conductors

Please rank topics in order of priority of importance to you.

Check "No opinion" if topic not relevant to you or of no interest.

	1	2	3	No opinion
99) extention of potential models	○	○	○	○
100) water and mechanical properties	○	○	○	○
101) effect of water on radiation damage	○	○	○	○

Comments

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33. Referring to above roadmaps, please assess the relative importance of 101 elements listed therein, and identify by corresponding number 3 to 8 elements in decreasing importance. Please list them in the box below:

Glass for Energy & Information Technology. Road Maps

34. The following 10 technologies were identified and discussed by the experts in the field. From the drop-down menu please rank the top 3 technologies where investment in additional glass R&D will enable significant growth. The most important technology should be identified as 1 from this menu, etc.

	Rank Top 3 Technologies
1. Lighting	
2. Photovoltaics	
3. Windows	
4. Energy storage (batteries/capacitors)	
5. Coatings (optical/TCO)	
6. Thin glass (r2r)	
7. Finishing	
8. Telecom/photonics	
9. Information storage	
10. Displays	

Comments

Glass for Energy & Information Technology. Road Maps

35. The following 14 topics of properties and processing were identified and discussed by the experts in the field. From the drop-down menu please rank the top 5 topics where fundamental research can have the broadest impact on energy and information technologies. The most important property/processing topic should be identified as 1 from this menu, etc.

	Rank top 5 topics
1. Substrates with functional coatings	
2. Sealing/encapsulation	
3. Chemical durability/surface	
4. Strong/damage resistant	
5. Ionic/electronic conduction	
6. Photo-activity/NLO	
7. Optical fibers/design and processing	
8. Glass-ceramics/crystallization	
9. Phosphate/sulfide/chalcogenide	
10. Laser interactions and processing	
11. Melting/quality and sustainability	
12. Computer modeling and simulation	
13. Thermochemical data	
14. Theory/understanding	

Comments