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5.2.1.3.2. Effects due to substrate choice (e.g. ATJ vs. TZM vs. ODS steel)

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5.2.2.2.2. QMB methods for net erosion/deposition

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5.2.3. Establish the science and operating scenarios of the strongly-emitting regime (Jaworski, Gray, Goldston, Soukhanovskii, Kaganovich, Chang, Stotler)

5.2.3.1. Motivation: fusion heat-fluxes on advanced PFCs expected to result in elevated temperatures and strong eroded fluxes from evaporation and sputtering, may no longer be in a minority-impurity plasma but a strongly-emitting PFC regime

5.2.3.2. Assessing lithium heat-flux reduction and radiation

5.2.3.2.1. Infrared thermography and other techniques for quantifying heat-flux

5.2.3.2.2. Vapor shielding of the PFC in steady-state and under transient loads

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5.2.4.3.1. Lithium laboratory work and testing for technological readiness, 4-research needs for LM-PFCs...

5.2.4.3.2. Technical demonstrations on linear test-stands (e.g. Magnum-PSI)

5.2.4.4. An all-metal NSTX-U (Jaworski, Kaita)

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5.2.5.1.2. Extending the database of lithium-enhanced performance with NSTX-U capabilities

5.2.5.1.3. Effects of expanded coverage using diffusive evap, LITER-U or other tools

5.2.5.1.4. Effect of up-down asymmetry of lithium evaporation

5.2.5.2. Assessing erosion from low-Z coatings and high-Z substrates

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5.2.5.2.2. Coating life-time and efficacy studies on carbon and high-Z metal substrate

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5.2.5.3.1. Establish power-balance

5.2.5.3.2. Studies ranging from no Li to heavy lithium coatings

5.2.5.3.3. Identification of key performance metrics (e.g. SOL midplane density, core Li content) with strong lithium effects in the SOL

5.2.5.4. Enabling R&D and laboratory studies

5.2.5.4.1. Lithium loop and mock PFC testing in vacuum systems

5.2.5.4.2. Surface-science studies of lithiated high-Z PFCs

5.2.5.4.3. Plasma exposures on linear test-stands and high-heat flux machines

5.2.5.4.4. Upgrade to partial high-Z coverage in NSTX-U with at least 1 divertor target

5.2.6. Plan: Years 3-5 (Jaworski, Skinner, Stotler, Kaita)

5.2.6.1. Assessing lithium performance enhancements in NSTX-U

5.2.6.1.1. Re-assess core performance metrics (e.g. confinement) with high-temperature, thick coatings on high-Z materials including flowing lithium divertor module

5.2.6.1.2. Assess particle control and impurity production in strongly-emitting PFC regime

5.2.6.2. Assessing erosion from low-Z coatings and high-Z substrates

5.2.6.2.1. Develop adequate plasma background for studying material transport

5.2.6.2.2. Determine high-Z erosion rates, transport and redeposition locations, mass balance

5.2.6.2.3. Determine lithium transport from emitting PFC locations – emission rates, redeposition locations, mass balance

5.2.6.3. Lithium radiation and effects on the SOL
- 5.2.6.3.1. Effect of strongly-emitting PFCs on SOL and divertor
- 5.2.6.3.2. Establish power-balance
- 5.2.6.3.3. Determine optimum divertor configuration for strongly-emitting regime

5.2.6.4. Enabling R&D and laboratory studies
- 5.2.6.4.1. Offline design validation of actively wetted, actively cooled liquid metal PFC
- 5.2.6.4.2. Either movable limiter module (year 3) or divertor module (year 4) implementation
- 5.2.6.4.3. Surface-science of redeposited/codeposited materials, high-Z and low-Z materials
- 5.2.6.4.4. Increased high-Z substrate coverage, all-metal divertor
- 5.2.6.4.5. Assessment of tile-coating technology for wall replacement

5.3. Summary timeline for tool development to achieve research goals (Jaworski)

5.4.

5.4.1. Theory and simulation capabilities (Stotler, Chang, Kaganovich, Jaworski, Skinner, Koel, Canik/Gray, Carter?, Soukhanovskii/Meier?, Pigarov?)

5.4.1.1. Fluid models of the edge plasma
- 5.4.1.1.1. SOLPS/ B2-EIRENE
- 5.4.1.1.2. UEDGE/WALLPSI
- 5.4.1.1.3. HEIGHTS
- 5.4.1.1.4. FACETS?
- 5.4.1.1.5. OEDGE (OSM+EIRENE+DIVIMP)
- 5.4.1.1.6. New tools (e.g. B2.5-Eunomia)

5.4.1.2. Kinetic models of the edge plasma
- 5.4.1.2.1. XGC0, XGC1
- 5.4.1.2.2. DEGAS2, EIRENE
- 5.4.1.2.3. EDIPIC/LSP

5.4.1.3. Core transport codes
- 5.4.1.3.1. NCLASS, MIST, STRAHL

5.4.1.4. Atomistic material modeling
- 5.4.1.4.1. MD
- 5.4.1.4.2. DFT
- 5.4.1.4.3. QCMD

5.4.1.5. PFC response codes
5.4.1.5.1. OpenFOAM
5.4.1.5.2. ANSYS/CFX

5.4.2. Diagnostics (Kaita, Jaworski, Skinner, Koel, Allain)
5.4.2.1. Plasma diagnostics
5.4.2.1.1. Baseline: Langmuir probes, spectroscopy, fast-cameras, line-scan cameras, filterscopes, IR thermography, core CHERS, core spectroscopy
5.4.2.1.2. High-priority upgrades: eroding thermocouples, bolometers, spectrally-resolved divertor radiometers, plasma flow diagnostics, divertor Thomson OR other Ne, Te capability, improved neutral quantification in the edge and divertor

5.4.2.2. Material diagnostics
5.4.2.2.1. Baseline: MAPP capabilities (TPD, XPS, LEISS), laboratory-based capabilities: AES, HREELS,(Koel lab+PU), QMBs
5.4.2.2.2. High-priority upgrades: in-situ liquid-metal surface quality, in-situ surface composition (e.g. LIBS/LIDS/LABS), marker tiles

5.4.3. Lithium-PFC supporting technologies (Jaworski, Skinner, Mansfield?, Andruczyk)
5.4.3.1. LITER-FAST/LITER-UPWARD, diffusive evaporation
5.4.3.2. Lithium granule injector
5.4.3.3. Electrostatic injection
5.4.3.4. LM-PFC and loop development

5.5. Summary and recapitulation (Jaworski, Menard)
5.5.1. Looking to the NSTX-U 10yr plan
5.5.2. Impact on FNSF-class devices