WONIK MATERIALS
North America

R&D Capabilities

Germantown, WI

Linx ESG Conf 2020

R&D Synthesis Expertise

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- Silicon – chlorosilanes, aminosilanes, organosilicon compounds and substituted silanes
  - Standard precursors for SiO2 and SiN (BDEAS, 3DMAS, BTBAS, HCDS, OCTS, HCDSO, etc.)
    - Method for manufacturing of aminosilanes patent is pending
  - BDIPADS - novel precursor for low-T SiO2 (application patents JKP-0365, US 2018/0371612 A1)
  - BIPTS – novel precursor for low-T SiN
  - OCTSO – precursor for SiO2, SiON
  - 4TCSS and 3TCSS – precursors for poly-Si and SiN
- Organometallic compounds of main group metals (e.g. Li, Mg, Al)
  - Magnesium bis(dimethylaminodiboronate) - precursor for Mg or MgB
- Inorganic and Organometallic compounds of early and late transition metals (e.g. Ti, Hf, Zr, V, Ta, Nb, Mo, W, Ni, Co, Mn)
  - Developed synthesis methods for standard molecules
  - R&D discovery work in progress for metallization precursors (e.g. Ru, Co)
  - Starting R&D discovery work for TiN precursors
- Specialty compounds of other elements, such as B, As, Se, Te
- Ligand synthesis for metal compounds
- 30+ products developed with complete master prep and pre-pilot plan, more than half of them is ready for industrial production

■ Precursor examples – Chlorosilanes and Chlorosiloxanes

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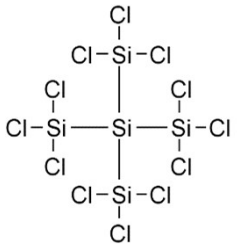
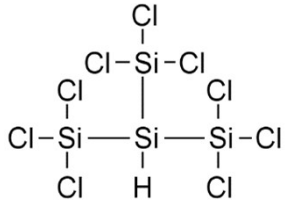
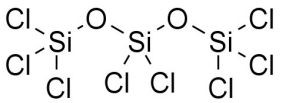
- Tetrakis(trichlorosilyl)silane (4TCSS)
  - Solid product (M.p. 55 °C), easily made on kilo scale from the waste stream of HCDS production
  - Potential application in poly-Si or SiN depositions
  - Used as a starter in neo-pentasilane production (Si_5H_{12})



- Tris(trichlorosilyl)silane (3TCSS)
  - Low melting solid (M.p. 30 °C), volatile (VP 1 torr@ 75 °C), made from the waste stream of HCDS production
  - Potential application in poly-Si or SiN depositions



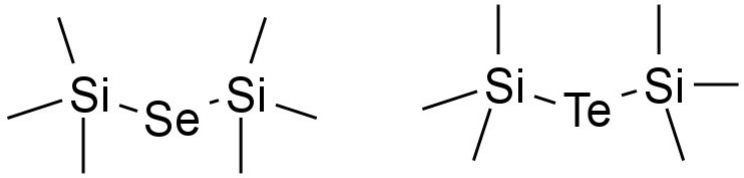
- Octachlorotrisiloxane (OCTSO)
  - Colorless liquid (B.p. 184 °C), volatile (VP 1 torr @ 26 °C), by-product of HCDSO production
  - Potential application in SiON, SiO_2 capping layer depositions and coating



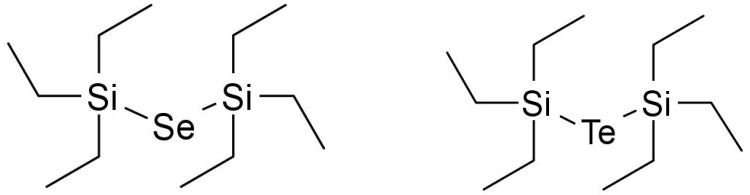
Precursor examples - Se and Te products

- Se and Te precursors are used as:
  - Se and Te source in Mo and W chalcogenide films (2D materials)
  - Dopants in quantum dot devices
  - Se and Te source in optical materials (e.g GIST, $GeTe_2$)

- Current offer – 5 products (relatively known, standard compounds)
  - Bis(trimethylsilyl) selenide or telluride, BTMSSe, BTMSTe
    - Our **BTMSTe** was recently used in deposition of **$GeTe_2$ layers**, results presented by IMI at ALD conference in Incheon, Korea, in July 2018



  - Bis(triethylsilyl) selenide or telluride, BTESSe, BTESTe



  - Dimethylselenide, DMSe Me–Se–Me

- Work in progress on new, non-silyl based compounds

Thank you!