Fabrication of LOW WATER PEAK MCVD Fibers

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Why Low Water Peak Fibers ? (1)

The breakthrough of DWDM (dense wavelength division multiplexing) technology has changed the fiber market:

- **use of large number of channels imposes new requirements on fiber quality:**
  - the so-called extended band (E-band) in the wavelength window between 1360 nm and 1460 nm has to be made available for multi-channel communications
  - to enable this, the water peak at 1385 nm has to be reduced below the level of highest attenuation in the second transmission window (1270 nm to 1330 nm)
- **OVD and VAD made fibers reach this requirement without difficulty due to consolidation (drying) process, which ensures very low level of hydroxyl ion incorporation in the silica glass lattice**
- **MCVD made fibers can fulfill these specifications even though MCVD core preforms cannot be produced by using a similar drying process:**
  - raw material specifications have to be adapted
  - improvements to fabrication procedures have to be used in all stages of preform and fiber fabrication process
  - preform fabrication equipment has to be upgraded

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Water Peak in MCVD Fibers (2)

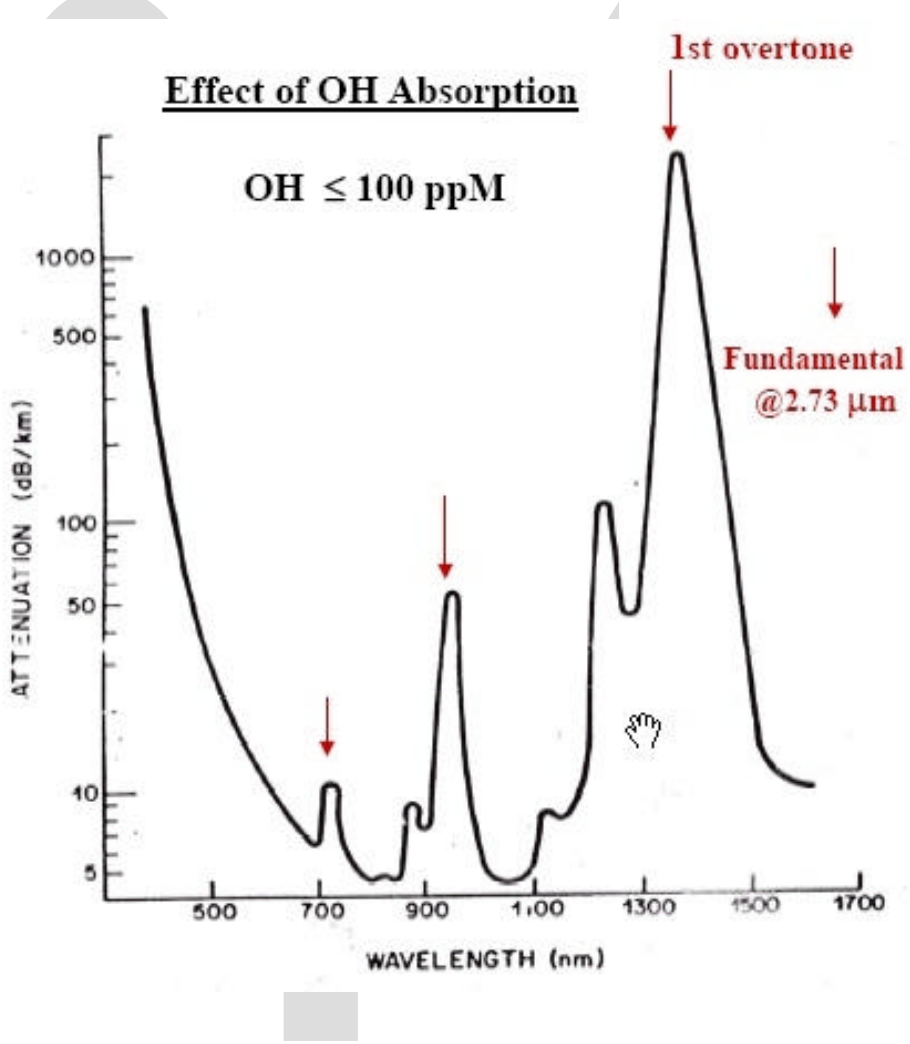
Water peak is an absorption peak caused by vibrational transitions of Si-OH molecules in the silica glass lattice:

- these molecules are generated by incorporation of hydroxyl into the glass structure
- the attenuation is caused only in the region where light propagates, i.e. in the optical fiber core and in narrow region of the optical cladding surrounding the core
- impurities arrive into the core and cladding area through direct contamination of deposited layers or by diffusion from regions with high impurity concentration

Possible sources during MCVD preform fabrication process are:

- **raw materials:**
  - gases, liquid reagents and quartz
- **handling and preparation procedures:**
  - tube and preform welding, polishing and storage, handling of raw materials and chemicals
- **fabrication process:**
  - leakage of gas conduits or components, degassing
- **diffusion during high temperature processes:**
  - hydroxyl (and especially hydrogen) can diffuse easily through silica glass lattice at elevated temperatures
  - whenever preform is heated up during fiber fabrication process, hydroxyl diffuses from the regions with high hydroxyl concentration to adjacent regions with lower concentration
  - to prevent diffusion of hydroxyl ions from substrate tube (or tube- cladding interface) to the preform core, a thick barrier layer of silica glass has to be laid down between the tube and the optical core, a time-consuming process that reduced the productivity of MCVD process and makes deposition of core layers more complex

Effect of Hydroxyl on Fiber Attenuation (3)



OH- vibrational absorption peak (stretching the chemical bond) causes increase in fiber attenuation:

For every 1 ppmv of OH- in silica by:

- 48 dB/km @ 1385 nm
- 2,5 dB/km @ 1240 nm
- <0,1 dB/km @ 1600 nm

When doped with Ge:

- overtone at 1420 nm widens the silica based water peak

When doped with P:

- widening of peak between 1500 nm and 1600 nm, making third transmission window dark !

Reducing Water Peak in MCVD Fibers (4)

Reducing water peak in MCVD produced fiber is a complex task made of a number of related activities:

- **upgrade raw material specifications**
  - raw material specifications need to be checked and upgraded
- **development and introduction of proper material and product handling procedures**
  - glass working operations
  - tube and preform cleaning operations
  - refill material exchange operations
- **upgrade equipment and accessories used in preform fabrication process**
  - use improved rotary joint
  - prevent degassing and leakage in piping system and components
  - eliminate all possible sources of hydroxyl or hydrogen from process
- **use proper preform fabrication recipes and procedures**
  - carefully design cladding barrier layer thickness
  - prevent, eliminate or reduce steps requiring high temperature
- **improve fiber drawing procedures to minimize effect of hydroxyl diffusion**

Optacore offers support in introducing these improvements in production of low water peak MCVD fibers.

We are looking forward to hear from you !

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