

EXTRALUM

Technical Bulletin.

Spontaneous Breakage of Tempered Glass.

Introduction.

Circumstantially there are known cases in which tempered glass "exploded without any external intervention, for no apparent reason" (see [Figure 1](#)) and although it is unusual, this is possible and has clear and documented scientific and technical reasons. The phenomenon is known as *spontaneous Breakage of Tempered Glass*.

The first recorded and documented case was in the "ICI House Melbourne" building in Australia during the 1950s ⁽¹⁾.



[Image 1](#). Typical break pattern by spontaneous breakage.

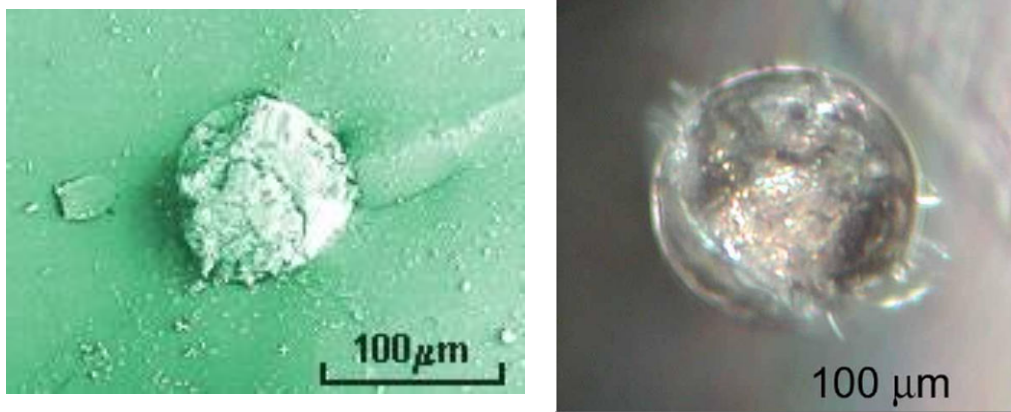
Description.

All float glass contains some level of defects, including stones and bubbles, which are an inevitable part of the glass manufacturing process. One type of stone (crystalline) is nickel sulfide ("NiS"). Nickel can be present in any batch of glass, derived from the nickel strokes present in the sand, fuel and even from the machinery used to mix the raw material. Sulfide can come from fuel or sodium sulfate, one of the ingredients in glass manufacturing. When NiS is present, the amount is extremely small.

Most NiS stones are stable and do not cause problems. However, there are a small number of NiS stones, which when slowly cooled from 400°C to room temperature, undergoes a change in its crystal structure (phase change) that results in an increase in volume.

In the tempering process, rapid cooling (thermal shock) traps NiS inclusions in their compressed phase. Without no advice, these inclusions can return to their original state (expand), in a transformation that can increase their volume by up to 4%. When inclusion is in the central stress area of tempered glass, this increase in volume could cause a sufficient stress increase (tension) to break the glass.

Spontaneous breakage in tempered glass can happen at any time, without the need to apply a load or tension, in the short term or even five or ten years after manufacture. These inclusions are so small (about 0.03mm in diameter, see [Figure 2](#)) that, in practice, they are impossible to locate and identify them in the glass before or after the tempering process.



[Image 2](#). Two cases of inclusion of NiS particles.

Very recently, more precisely in the last two years, the "classic" theory of spontaneous breakage has been changed, when a new agent or motive generating it was discovered, called "Silicon Monolithic Particle".

The use of state-of-the-art technologies such as the visualization of spontaneous breakage processes using electron microscopes allowed to discover indirectly the presence of these particles, exactly in the center of the fracture, with typical "butterfly" pattern. (see [Figure 3](#)).

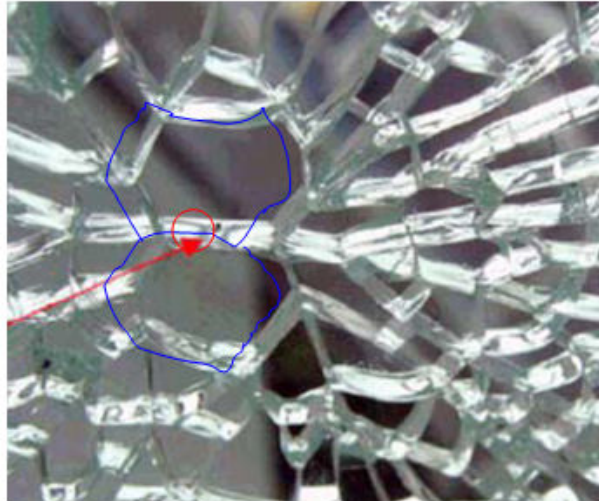


Image3. Typical pattern of spontaneous “butterfly” breakage and the monolithic silicon particle, which generates the explosion

The expansion coefficient of monolithic silicon particles is twice as large as that of the tempered glass matrix, so the expansion phenomenon described above for NiS occurs equivalently. They have an average dimension of 0.3mm and under the electron microscope they are visualized as in Image 4:

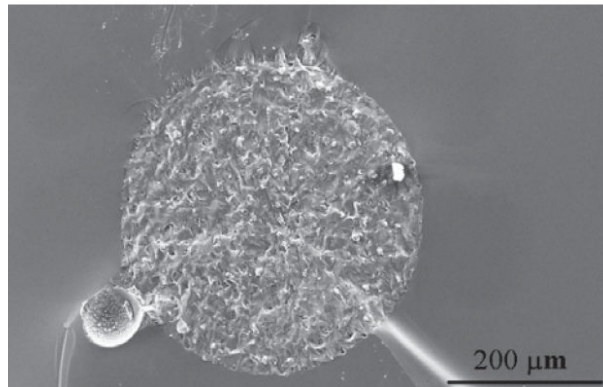


Image4. Silicon monolithic particle.

The absence of NiS and monolithic silicon particles in the glass cannot be guaranteed by any manufacturer, as their presence is imperceptible and unpredictable.

A good design should recognize this fact and specify the use of tempered glass in applications where spontaneous breakage does not cause major safety and functionality problems. Architects and engineers can minimize the risk of serious problems due to spontaneous breakage by recommending heat-strengthened glass and laminated glass in critical applications.

The Extralum S.A. tempered glass offers clearly indicate the (low) probability of spontaneous breakage. Glaziers and Designers must transmit this probability to building owners and homeowners too.

References and Bibliography.

(1) “Fracture of Toughened Glass Wall Cladding, ICI House Melbourne” - *E.R.Ballantyn* – Australian CSIRO Division of Building Research, Report No. 061-4, 1961.

“Another Cause for Spontaneous Breakage of tempered Glass – Silicon Particles in Tensile Zone” - *Dr. BAO Yiwang, Mr. YANG Jianjun, Mr. SHI Xinyong* – GLASS PERFORMANCE DAYS 2007.

“A Review of the Nickel Sulphide Induced Fracture in Tempered Glass” – *Dr. Leon Jacob* – Jacob & Associates Pty Ltd – Glass Processing Days, Poster 10 – 2001.

If you have any questions, consult the Sales Department of Extralum, S.A.