Hidden colored Building Integrated Photovoltaics: technology overview and design challenges

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Technological solution for hidden coloured BIPV

Transforming the building stock into nearly zero or positive energy is a key aspect to meet the decarbonization targets worldwide. High customizable BIPV technologies guarantee larger aesthetical possibilities, required by architectural applications to ensure flexibility in the design. The ability of BIPV products to match the architectural language through different shapes, dimensions, colours, and textures represent a clear advantage for BIPV integration in the building envelope. Different customization techniques to obtain coloured or textured BIPV modules are currently used and they mainly differ from the position and kind of coloured layer used for manufacturing (Fig.2). Coloured additional layers can be used in the lamination of several BIPV technologies, including crystalline and amorphous silicon, thin-film, perovskite. Among interposed coloured layers, some present almost endless customization possibilities, such as BIPV modules with printed, coated or finished front glass (Fig.1), polymeric interlayer or textile additional layers that can be digitally printed. This kind of technology, can guarantee a higher level of flexibility in the design choices, while relaying on robust and efficient technology, such as c-Si PV cells as active layer.

Customized colours and patterns for BIPV

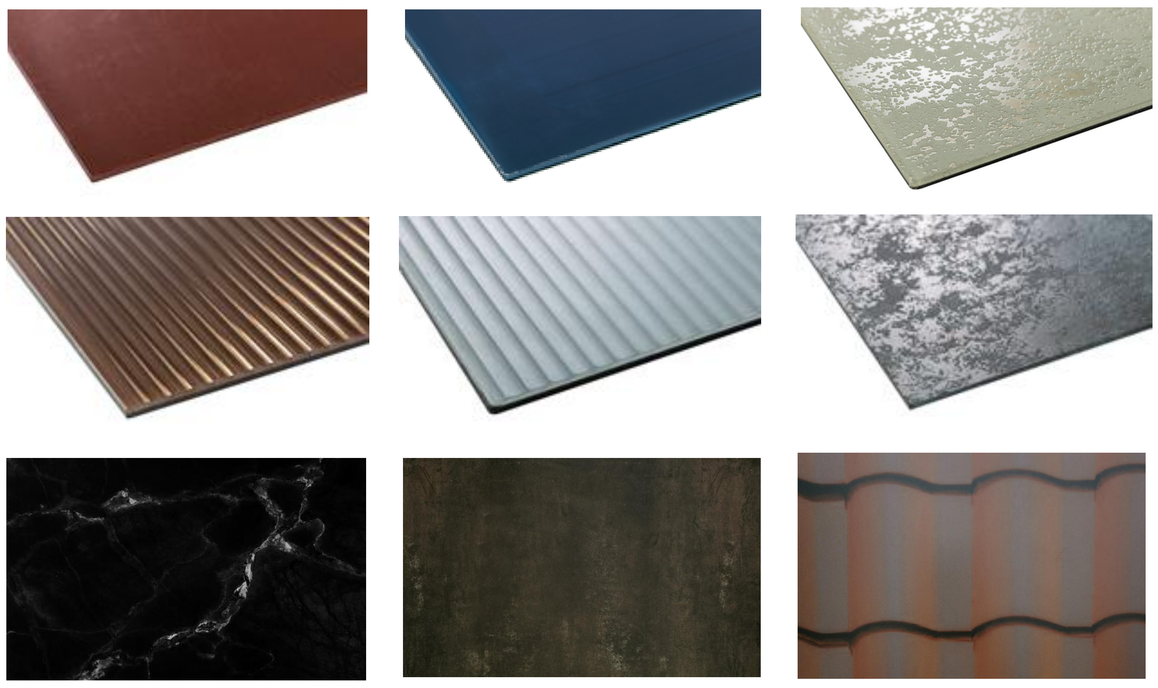

Fig. 1. Examples of customized colors and patterns. From the top left: terracotta color, grayish-blue color, sanded light green, vertical lines bronze, vertical line grey and sanding, marble pattern, cortex pattern, rooftiles pattern. Images courtesy of SUNAGE.

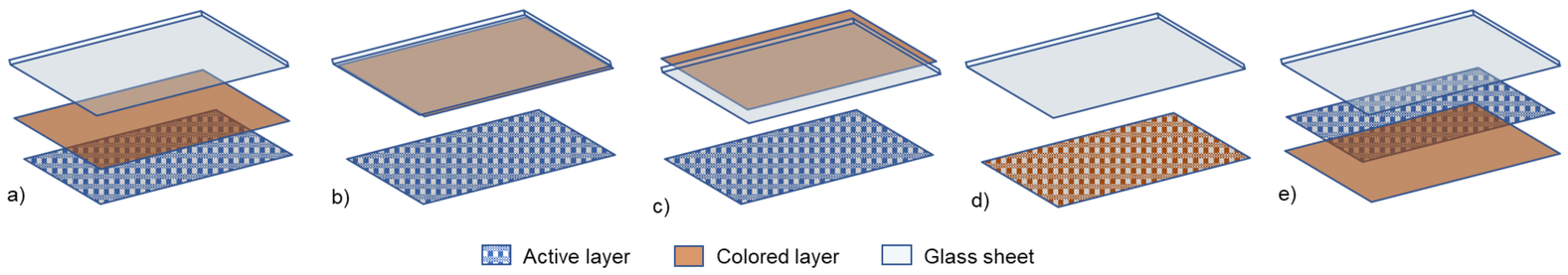

Fig. 2. Schematization of the customization techniques to obtain coloured or textured BIPV modules: a) coloured interlayer or encapsulant; b) coloured coated front glass; c) coloured layer on top of the front glass; d) coloured or coated active layer; e) coloured back sheet.

Design challenges for BIPV architectural integration

To obtain the best results out of BIPV installation, designers must consider the energy generated by the modules as a part of an integrated design process, that includes architectural, technological and energy aspects. Moreover, since every building is different, in terms of shape, landscape context, size, function, etc., the design of BIPV systems should also consider the context in which the PV modules are applied. For example, the integration of BIPV modules with a shining finish on the façade of a building could cause glare problems to the surroundings, and this is particularly critical in dense urban environments and in presence of high traffic streets. The most challenging aspects to be considered are the ones related to aesthetic integration, which, as said, could affect all the design levels.

DIMENSION

The use of standard single-sized BIPV modules on building facades is prevented by numerous obstacles such as windows, doors, roof pitches, etc. For this reason, the BIPV modules must adapt to the geometry of the façade. In the case of renovations, however, the BIPV modules have to adapt to the geometry of the existing façade. Consideration should be given to the required electrical system consisting of PV cells and electrical connections. If the architectural design requires module dimensions that are too small to accommodate the circuit board with the PV cells while complying with the specific standard, passive PV modules that are aesthetically identical to active modules but without PV cells must be manufactured, to guarantee chromatic and materic uniformity to the façade.

FINISHING

Architects and designers can also customize the finish of the front glass. Shining glass that may cause glare in the surrounding area because of its high reflectance, while sating glass provide antireflective feature allowing an easier integration into all vertical and horizontal surfaces of the building. It is also possible to have structured glass with tridimensional patterns.

COLOUR

It is possible to reproduce the pattern or a high-resolution photograph of traditional building materials to provide aesthetical integration where landscape constraints are present. Each colour has a different effect on the efficiency of the PV modules. The electrical specifications of modules with customized colour are usually determined by post-production tests, and they must be carefully considered in the energy design of the integrated BIPV system.



Fig. 3. Pregassona project, Switzerland, by Arch. Rosario Galgano. Images courtesy of SUNAGE.

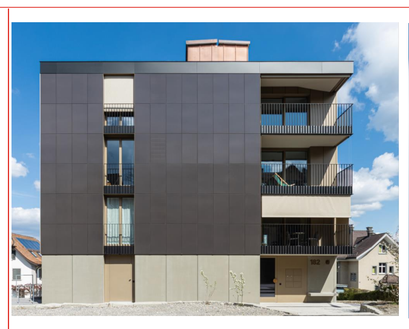
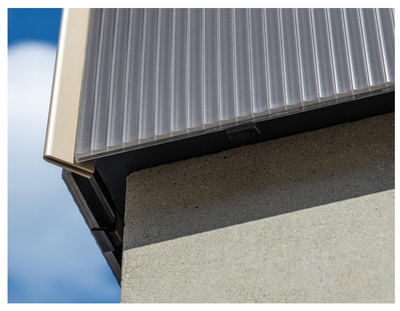


Fig. 4. Thalwil project, Switzerland, by Tobler Litscher GmbH firm. Images courtesy of SUNAGE.



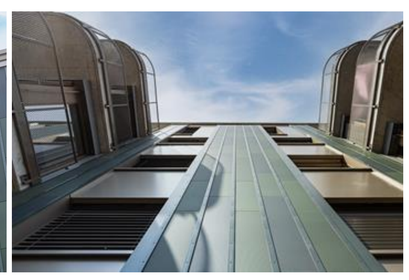

Fig. 5. Kloten project, Switzerland, by Arch. René Schmid. Images courtesy of SUNAGE.

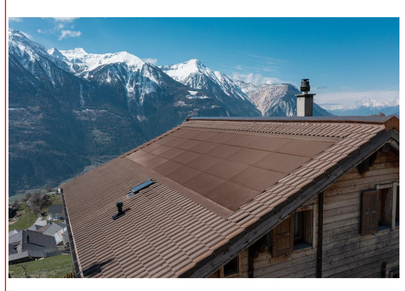
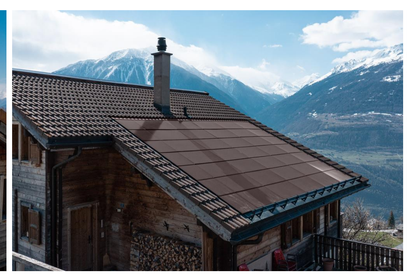


Fig. 6. Erschmatt project, Switzerland. Images courtesy of SUNAGE.